GEORGE EDWARD JOHNSON

(Obituary on page 28)

TRANSACTIONS

OF THE

KANSAS ACADEMY OF SCIENCE

VOLUME 38

F. C. GATES, *Editor*
W. J. BAUMGARTNER, *Managing Editor*

SIXTY-SEVENTH ANNUAL MEETING, MARCH 28-30, 1935

UNIVERSITY OF KANSAS, LAWRENCE, KAN.

Correspondence should be addressed as follows:

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Manhattan, Kansas, U. S. A.

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CONSTITUTION AND BYLAWS

CONSTITUTION *

SECTION 1. This association shall be called the Kansas Academy of Science.

SEC. 2. The objects of this Academy shall be to increase and diffuse knowledge in various departments of science.

SEC. 3. The membership of this Academy shall consist of three classes: annual, life and honorary.

(1) Annual members may be elected at any time by the committee on membership, which shall consist of the secretary and other members appointed, annually, by the president. Annual members shall pay annual dues of one dollar, but the secretary and treasurer shall be exempt from the payment of dues during the years of their service.

(2) Any person who shall have paid thirty dollars in annual dues, or equivalent due to legal exemption, or in one sum, or in any combination, may be elected to life membership, free of assessment, by a two-thirds vote of the members present at an annual meeting.

(3) Honorary members may be elected because of special prominence in science upon written recommendation of two members of the Academy, by a two-thirds vote of the members present. Honorary members pay no dues.

SEC. 4. The officers of this Academy shall be chosen by ballot at the annual meeting, and shall consist of a president, two vice-presidents, a secretary and a treasurer, who shall perform the duties usually pertaining to their respective offices. The president, the secretary and the treasurer shall constitute the executive committee. The secretary shall be in charge of all the books, collections and material property belonging to the Academy.

SEC. 5. Unless otherwise directed by the Academy, the annual meeting shall be held at such time and place as the executive committee shall designate. Other meetings may be called at the discretion of the executive committee.

SEC. 6. This constitution may be altered or amended at any annual meeting by a vote of three fourths of attending members of at least one year's standing. No question of amendment shall be decided on the day of its presentation.

SEC. 7. This Academy shall have an executive council consisting of the president, the secretary, the treasurer, the vice-presidents, the chairmen of the sections and the retiring president, and other members to be nominated by the nominating committee and elected as the other officers. This council shall have general oversight of the Academy not otherwise given by this Constitution to officers or committees.

SEC. 8. This Academy shall have an editorial board consisting of an editor, a managing editor, and four associate editors. These members shall be elected

* As modified by amendments.

in the same manner as other officers, but for a period of three years. Two members of the board shall be elected every year, except that in 1935 the editor and one associate shall be elected for three years, the managing editor and one associate for two years and two associates for one year each.

The editor, with the aid of the associate editors, shall have general supervision of all editorial work submitted for publication in the transactions, and shall be responsible for the selecting, editing, revision and rejection of papers submitted for publication. The managing editor shall be responsible for the making of the plates and the printing and general distribution of the Transactions.

BYLAWS

I. At the beginning of each annual session there shall be held a brief business meeting for announcements and appointment of committees. For the main business meeting, held later in the session, the following order is suggested:

1. Reports of officers
2. Reports of standing committees.
3. Unfinished business.
4. New business.
5. Reports of special committees.
6. Election of officers.
7. Election of life and honorary members.

II. The president shall deliver a public address on the evening of one of the days of the meeting, at the expiration of his term of office.

III. No meeting shall be held without a notice of the same having been published in the papers of the state at least thirty days previous.

IV. No bill against the Academy shall be paid by the treasurer without an order signed by the president and secretary.

V. Names of members more than one year in arrears in dues shall be dropped from the membership list.

VI. The secretary shall have charge of the distribution, sale and exchange of the published Transactions of the Academy, under such restrictions as may be imposed by the executive committee.

VII. Ten percent of the active membership shall constitute a quorum for the transaction of business. Section meetings may not be scheduled or held at the time a business meeting is called by the president at a general session or announced on the program.

VIII. The time allotted to the presentation of a single paper shall not exceed fifteen minutes.

IX. No paper shall be entitled to a place on the program unless the manuscript, or an abstract of the same, shall have been previously delivered to the secretary.

X. Section programs may be arranged by the secretary with the advice of the section chairmen. The subdivision or combination of existing sections shall be dependent upon the number of papers to be presented. Such changes

shall be made by the secretary in accordance with the policies of the Academy and after receiving the advice of the chairmen of the sections concerned.

XI. Section chairmen for the ensuing year shall be elected annually at the close of the section meetings.

XII. Section programs shall be limited to Friday afternoon of the annual session, but may be continued Saturday afternoon if desired by the section chairman. Exceptions to this must receive the approval of the executive committee.

PAST OFFICERS OF THE ACADEMY

Year.	President.	First Vice-president.	Second Vice-president.	Secretary.	Treasurer.
1869	B. F. Mudge	J. S. Whitman		J. D. Parker	F. H. Snow
1870	B. F. Mudge	J. S. Whitman		J. D. Parker	F. H. Snow
1871	John Fraser	B. F. Mudge		J. D. Parker	F. H. Snow
1872	John Fraser	B. F. Mudge	R. J. Brown	J. D. Parker	F. H. Snow
1873	John Fraser	B. F. Mudge	R. J. Brown	J. D. Parker	F. H. Snow
1874	F. H. Snow	J. A. Banfield	J. D. Parker	John Wherrell	R. J. Brown
1875	F. H. Snow	B. F. Mudge	J. D. Parker	John Wherrell	R. J. Brown
1876	F. H. Snow	B. F. Mudge	J. H. Carruth	Joseph Savage	R. J. Brown
1877	F. H. Snow	B. F. Mudge	J. H. Carruth	Joseph Savage	R. J. Brown
1878	F. H. Snow	B. F. Mudge	J. H. Carruth	E. A. Popenoe	R. J. Brown
1879	B. F. Mudge	J. H. Carruth	Joseph Savage	E. A. Popenoe	R. J. Brown
1880	B. F. Mudge	J. H. Carruth	Joseph Savage	E. A. Popenoe	R. J. Brown
1881	J. T. Lovewell	J. H. Carruth	Joseph Savage	E. A. Popenoe	R. J. Brown
1882	J. T. Lovewell	J. H. Carruth	Joseph Savage	E. A. Popenoe	R. J. Brown
1883	A. H. Thompson	J. R. Mead	G. E. Patrick	E. A. Popenoe	R. J. Brown
1884	R. J. Brown	F. H. Snow	Joseph Savage	E. A. Popenoe	A. H. Thompson
1885	R. J. Brown	E. L. Nichols	G. H. Failyer	E. A. Popenoe	A. H. Thompson
1886	E. L. Nichols	J. D. Parker	N. S. Goss	E. A. Popenoe	I. D. Graham
1887	J. D. Parker	J. R. Mead	E. H. S. Bailey	E. A. Popenoe	I. D. Graham
1888	J. R. Mead	E. H. S. Bailey	T. H. Dinsmore, Jr.	E. A. Popenoe	I. D. Graham
1889	T. H. Dinsmore, Jr.	E. H. S. Bailey	G. H. Failyer	E. A. Popenoe	I. D. Graham
1890	G. H. Failyer	D. S. Kelly	F. W. Cragin	E. H. S. Bailey	I. D. Graham
1891	Robert Hay	F. W. Cragin	O. C. Charlton	E. H. S. Bailey	F. O. Marvin
1892	E. A. Popenoe	F. O. Marvin	Mrs N. S. Kedzie	E. H. S. Bailey	D. S. Kelly
1893	E. H. S. Bailey	J. T. Willard	E. B. Kneer	A. M. Collete	D. S. Kelly
1894	L. E. Sayre	I. D. Graham	J. L. Howitt	E. B. Kneer	D. S. Kelly
1895	Warren Knaus	I. D. Graham	S. W. Williston	E. B. Kneer	D. S. Kelly
1896	D. S. Kelly	S. W. Williston	D. E. Lantz	E. B. Kneer	L. E. Sayre
1897	S. W. Williston	D. E. Lantz	A. S. Hitchcock	E. B. Kneer	J. W. Beede
1898	D. E. Lantz	C. S. Parmenter	L. C. Wooster	E. B. Kneer	J. W. Beede
1899	E. B. Kneer	A. S. Hitchcock	J. R. Mead	D. E. Lantz	J. W. Beede
1900	A. S. Hitchcock	E. Miller	J. C. Cooper	D. E. Lantz	J. W. Beede
1901	E. Miller	J. C. Cooper	L. C. Wooster	D. E. Lantz	E. C. Franklin
1902	J. T. Willard	Edward Bartow	J. A. Yates	G. P. Grimsley	E. C. Franklin
1903	J. C. Cooper	Edward Bartow	J. A. Yates	G. P. Grimsley	Alva J. Smith
1904	Edward Bartow	L. C. Wooster	B. F. Eyer	G. P. Grimsley	Alva J. Smith
1905	L. C. Wooster	F. W. Bushong	W. A. Harshbarger	J. T. Lovewell	Alva J. Smith
1906	F. O. Marvin	B. F. Eyer	J. E. Welin	J. T. Lovewell	Alva J. Smith
1907	J. A. Yates	E. Haworth	F. B. Dains	J. T. Lovewell	Alva J. Smith
1908	E. Haworth	F. B. Dains	J. M. McWharf	J. T. Lovewell	Alva J. Smith
1909	F. B. Dains	J. M. McWharf	Alva J. Smith	J. T. Lovewell	F. W. Bushong
1910	F. B. Dains	J. M. McWharf	Alva J. Smith	J. T. Lovewell	F. W. Bushong
1911	J. M. McWharf	Alva J. Smith	J. E. Welin	J. T. Lovewell	F. W. Bushong
1912	F. W. Bushong	Alva J. Smith	J. E. Welin	J. T. Lovewell	L. D. Havenhill
1913	Alva J. Smith	W. A. Harshbarger	J. A. G. Shirk	J. T. Lovewell	L. D. Havenhill
1914	W. A. Harshbarger	J. A. G. Shirk	J. E. Todd	J. T. Lovewell	L. D. Havenhill
1915-1916	J. A. G. Shirk	J. E. Todd	F. U. G. Agrelius	J. T. Lovewell	L. D. Havenhill
1916-1917	J. E. Todd	F. U. G. Agrelius	L. D. Havenhill	W. W. Swingle	W. A. Harshbarger
1917-1918	F. U. G. Agrelius	L. D. Havenhill	B. M. Allen	W. W. Swingle H. W. Swingle Guy West Wilson	W. A. Harshbarger
1918-1919	L. D. Havenhill	R. K. Nabours	B. M. Allen	Guy West Wilson	F. C. Bruchmiller
1919-1920	R. K. Nabours	B. M. Allen	O. P. Dellinger	E. A. White	L. D. Havenhill
1920-1921	O. P. Dellinger	Roy Rankin	W. P. Hays	E. A. White	L. D. Havenhill
1921-1922	Roy Rankin	R. K. Nabours	W. R. B. Robertson	E. A. White	L. D. Havenhill
1922-1923	R. K. Nabours	H. P. Cady	H. H. Nininger	E. A. White	L. D. Havenhill
1923-1924	H. P. Cady	H. H. Nininger	J. E. Ackert	E. A. White	L. D. Havenhill
1924-1925	H. H. Nininger	J. E. Ackert	F. U. G. Agrelius	E. A. White	L. D. Havenhill
1925-1926	J. E. Ackert	H. M. Elsey	W. M. Goldsmith	E. A. White	L. D. Havenhill
1926-1927	H J. Harnly	Mary T Harman	L. D. Wooster	E. A. White	L. D. Havenhill
1927-1928	Mary T. Harman	L. D. Wooster	W. B. Wilson	E. A. White	L. D. Havenhill
1928-1929	L. D. Wooster	W. B. Wilson	Hazel E. Branch	G. E. Johnson	L. D. Havenhill
1929-1930	W. B. Wilson	Hazel E. Branch	W. M. Goldsmith	G. E. Johnson	R. Q. Brewster
1930-1931	Hazel E. Branch	Roger C. Smith	W. H. Matthews	G. E. Johnson	R. Q. Brewster
1931-1932	Roger C. Smith	W. J. Baumgartner	J. W. Hershey	G. E. Johnson	R. Q. Brewster
1932-1933	Robert Taft	J. W. Hershey	W. H. Matthews	G. E. Johnson	H. A. Zinszer
1933-1934	J. W. Hershey	W. H. Matthews	E. A. Marten	G. E. Johnson	H. A. Zinszer
1934-1935	W. H. Matthews	E. A. Marten	W. J. Baumgartner	G. E. Johnson F. C. Gates	H. A. Zinszer
1935-1936	W. J. Baumgartner	L. Oncley	H. H. Hall	Roger C. Smith	H. A. Zinszer

NOTE.—Previous to 1931-'32 the secretary was also editor. Since 1931-'32 F. C. Gates has been editor.

MEMBERSHIP OF THE ACADEMY

May 25, 1935

ABBREVIATIONS: The following abbreviations for institutions have been used:

U. of K.: University of Kansas.
K. S. C.: Kansas State College of Agriculture and Applied Science.
K. S. T. C.: Kansas State Teachers College.
F. H. K. S. C.: Fort Hays Kansas State College.
H. S.: High School.
Jr. H. S.: Junior High School.
Jr. Col.: Junior College.

Other abbreviations follow those used in the Summarized Proceedings of the American Association for the Advancement of Science.

The year given indicates the time of election to membership.

HONORARY MEMBERS

Barber, Marshall A., Ph. D., 1904, Internat. Health Div., Rockefeller Found., 49 W. Forty-ninth street, New York, N. Y.

Cockerell, T. D. A., D. Sc., 1908, prof. zoölogy (emeritus), Univ. Colorado, Boulder, Colo.

Franklin, Edward Curtis, Ph. D., 1884, prof. chemistry, Leland Stanford, Jr., Univ., Cal.

Grimsley, G. P., Ph. D., 1896, geological eng., B. & O. R. R., 4405 Underwood Road (Guilford), Baltimore, Md.

Hitchcock, A. S., Sc. D., 1892, principal botanist, U. S. Dept. Agric., Washington, D. C. (Deceased, December 16, 1935.)

Kellogg, Vernon L., LL. D., Sc. D., 1920, permanent secretary emeritus, National Research Council, Washington, D. C. (2305 Bancroft Place.)

McClung, C. E., Ph. D., 1903, dir. zoölogy lab., Univ. Pennsylvania, Philadelphia, Pa.

McCollum, E. V., Ph. D., Sc. D., 1902, prof. biochemistry, Johns Hopkins Univ., Baltimore, Md.

Nichols, Edward L., Ph. D., Sc. D., 1885 (honorary member 1897), prof. physics (emeritus). Cornell Univ., Ithaca, N. Y.

Riggs, Elmer S., M. A., 1896, assoc. curator paleontology, Field Mus. Nat. Hist., Chicago, Ill.

Wagner, George, M. A., 1897 (honorary member 1904), prof. zoölogy, Univ. Wisconsin, Madison, Wis.

LIFE MEMBERS

Agrelius, Frank U. G., M. A., 1905, assoc. prof. biol., K. S. T. C., Emporia, Kan.

Allen, Herman Camp, Ph. D., 1904, prof. chemistry, U. of K., Lawrence, Kan.

Bartholomew, Elam, Sc. D., 1896. (Deceased.)

Bartow, Edward, Ph. D., Sc. D., 1897, prof. and head Dept. Chem. and Chem. Eng., State Univ. Iowa, Iowa City, Iowa.

Baumgartner, William J., Ph. D., 1904, prof. zoölogy, U. of K., Lawrence, Kan.

Beede, Joshua W., Ph. D., 1894, prof. geology and paleontology, Indiana Univ., Bloomington, Ind.

Berry, Sister M. Sebastion, A. B., 1911, Supt. Schools, St. Paul, Kan.

Bushnell, Leland D., Ph. D., 1908, prof. and head Bacteriology Dept., K. S. C., Manhattan, Kan.

Bushong, F. W., Sc. D., 1896, 2636 Fifth street, Port Arthur, Tex.

Cady, Hamilton P., Ph. D., 1904, prof. chemistry, U. of K., Lawrence, Kan.

Cook, W. A., M. S., 1907, real estate business, 1414 Highland street, Salina, Kan.

Copley, Rev. John T., 1903, Olathe, Kan.

Cragin, F. W., Ph. D., 1880, 912 Miguel street, Colorado Springs, Colo.

Dains, Frank Burnett, Ph. D., 1902, prof. chemistry, U. of K., Lawrence, Kan.

Deere, Emil O., M. S., 1905, dean and prof. biology, Bethany Col., Lindsborg, Kan.

Dellinger, Orris P., Ph. D., 1909, prof. biology, K. S. T. C., Pittsburg, Kan.
Dunlevy, R. B., M. A., 1896, Southwestern Col., Winfield, Kan.
Eby, J. Whit, B. S., 1903, banker, Howard, Kan.
Failyer, George H., M. S., 1878, retired, R. R. 4, Manhattan, Kan.
Faragher, Warren F., Ph. D., 1927, asst. chief, Research Dept., Vacuum Oil Co., Inc., Paulsboro, N. J.
Garrett, A. O., M. A., 1901, head Dept. Biology, East High School, Salt Lake City, Utah.
Graham, I. D., M. S., 1879, State Board of Agric., Topeka, Kan.
Harman, Mary T., Ph. D., 1912, prof. zoölogy, K. S. C., Manhattan, Kan.
Harnly, Henry J., Ph. D., 1893, prof. biology, McPherson Col., McPherson, Kan.
Harshbarger, William A., Sc. D., 1903, prof. mathematics, Washburn Col., Topeka, Kan.
Havenhill, L. D., Ph. C., 1904, dean School of Pharmacy, U. of K., Lawrence, Kan.
King, H. H., Ph. D., 1909, prof. and head Dept. Chemistry, K. S. C., Manhattan, Kan.
Knaus, Warren M., D. Sc., 1882, *entomologist, editor Democrat Opinion*, McPherson, Kan.
McWharf, J. M., M. D., 1902. (Deceased.)
Meeker, Grace R., 1899, 709 S. Mulberry, Ottawa, Kan.
Menninger, C. F., M. D., 1903, 3617 W. Sixth avenue, Topeka, Kan.
Nabours, Robert K., Ph. D., 1910, prof. and head Zoölogy Dept., K. S. C., Manhattan, Kan.
Nissen, A. M., A. B., 1888, farmer, Wetmore, Kan.
Peace, Larry M., 1904, 512 W. Ninth street, Lawrence, Kan.
Reagan, Albert B., Ph. D., 1904, special prof. anthropology, Brigham Young Univ., Provo, Utah.
Robertson, W. R. B., Ph. D., 1905, Anat. Dept., Univ. Iowa, Iowa City, Iowa.
Schaffner, John H., M. S., 1903, research and prof. botany, Ohio State Univ., Columbus, Ohio.
Scheffer, Theodore, M. A., 1903, assoc. biologist, U. S. Biological Survey, Puyallup, Wash.
Shirk, J. A. G., 1904, prof. mathematics, K. S. T. C., Pittsburg, Kan.
Smith, Alva J., 1892, consulting eng., 810 Boylston street, Pasadena, Cal.
Smyth, E. Graywood, 1901, entomologist, Cia. Agricola Carabayllo, Hacienda Cartavio, Trujillo, Peru.
Smyth, Lumina C. R., Ph. D., 1902, 16802 Dartmouth, Cleveland, Ohio.
Sterling, Charles M., A. B., 1904, Lawrence, Kan. (Deceased.)
Sternberg, Charles H., M. A., 1896, 4046 Arizona street, San Diego, Cal.
Stevens, Wm. C., 1890, head Botany Dept., U. of K., Lawrence, Kan.
Welin, John Eric., D. Sc., 1889, prof. chemistry, Bethany Col., Lindsborg, Kan.
White, E. A., M. A., 1904, prof. chemistry, U. of K., Lawrence, Kan.
Willard, Julius T., D. Sc., 1883, vice-president K. S. C., Manhattan, Kan.
Wilson, William B., Sc. D., 1903, head Biology Dept., Ottawa Univ., Ottawa, Kan.
Wooster, Lyman C., Ph. D., 1889, prof. biology and geology (emeritus), K. S. T. C., Emporia, Kan.

ANNUAL MEMBERS

Members who paid their 1935 dues before May 21, 1935, are indicated by an asterisk (*). The year given is that of election to membership. If two years are given the second signifies reëlection.

*Ackert, James E., Ph. D., 1919, prof. zoölogy, parasitologist, dean Graduate Div., K. S. C., Manhattan, Kan.
*Adams, Myrl R., M. A., 1935, asst. instr., chemistry, U. of K., Lawrence, Kan.
*Aicher, L. C., B. S., 1930, supt. Fort Hays Branch, K. S. A. Expt. Sta., Hays, Kan.
*Albertson, F. W., 1935, assoc. prof. agr., F. H. K. S. C., Hays, Kan.
*Albright, Penrose, S., M. S., 1926, asst. prof. physics and chem., Southwestern Col., Winfield, Kan.
*Allegre, Charles, 1935, K. S. T. C., Emporia, Kan.
Aller, Alvin R., M. S., 1932, 607 E. Sixteenth street, Hutchinson, Kan.
*Alm, O. W., Ph. D., 1931, asso. prof. psychology, K. S. C., Manhattan, Kan.
*Alsop, M. L., M. S., 1932, teacher, H. S., Wamego, Kan.
*Aubel, C. E., M. S., 1933, asso. prof. animal husbandry, K. S. C., Manhattan, Kan.
*Ayres, H. D., Ph. D., 1928, head Dept. Physics, Univ. Wichita, Wichita, Kan.
*Ayers, Jane L., A. B., 1935, asst. botany, Washburn Col., Topeka, Kan.
*Babcock, Rodney W., Ph. D., 1931, dean, Div. Gen. Sci., K. S. C., Manhattan, Kan.
*Baden, Martin W., Sc. D., 1929, Box 520, Winfield, Kan.

Baker, Burton L., A. B., 1934, Columbia Univ., New York, N. Y.
Bardo, Carol, A. B., 1933, laboratory technician, 120 E. Washington avenue, Arkansas City, Kan.
*Barham, Harold N., Ph. D., 1931, assoc. prof. chemistry, K. S. C., Manhattan, Kan.
*Barnett, R. J., M. S., 1922, prof. horticulture, K. S. C., Manhattan, Kan.
*Barnhart, Carl, B. S., 1932, instr. H. S. East, Wichita, Kan.
*Barton, A. W., Ph. D., 1928, prof. botany, F. H. K. S. C., Hays, Kan.
*Bates, James, M. A., 1933, asst. instr. botany, U. of K., Lawrence, Kan.
Baxter, Walter, 1934, student, botany, U. of K., Lawrence, Kan.
*Beach, Edith, M. A., 1931, 812 Illinois street, Lawrence, Kan.
*Beaudry, David P., Sr., Santa Fe Railway Reptile Club, 708 Topeka, Ave., Topeka, Kan.
*Bell, John W., B. S., 1935, instructor Ind. Arts, High School, Walton, Kan.
*Benne, Kenneth, B. S., 1933, science teacher, H. S., Concordia, Kan.
*Bennett, Dewey, M. A., 1928, instr. biology and chemistry, Junior Col., Garden City, Kan.
*Black, Paul E., 1933, student, U. of K., Lawrence, Kan. (Olathe, Kan.)
*Blackman, L. E., Ph. D., 1935, head, Dept. Chemistry, K. S. T. C., Emporia, Kan.
*Bond, Glenn C., M. A., 1935, asst. instr. bacteriology, U. of K., Lawrence, Kan.
*Boughton, L. L., M. S., 1929, asst. prof. pharmacy, U. of K., Lawrence, Kan.
*Bowman, J. L., M. S., 1928, McPherson Col., McPherson, Kan.
*Boyce, Earnest, M. S., 1935, prof. civil engineering, U. of K., Lawrence, Kan.
*Branch, Hazel E., Ph. D., 1924, prof. zoölogy, Univ. Wichita, Wichita, Kan.
*Brennan, L. A., A. B., 1933, Andale, Kan.
*Breukelman, John, Ph. D., 1930, prof. biology, K. S. T. C., Emporia, Kan.
*Brewster, Ray Q., Ph. D., 1919, prof. chemistry, U. of K., Lawrence, Kan.
*Briscoe, Florence, 1935, student, U. of K., Lawrence, Kan.
*Brooks, Charles H., M. S., 1929, Extension Div., F. H. K. S. C., Hays, Kan.
Brooks, Frank M., 1934, student, Univ. Wichita, Wichita, Kan.
*Brown, Harold P., Ph. D., 1934, prof. chemistry, Univ. Kansas City, Kansas City, Mo.
*Brown, J. F., Ph. D., 1933, asst. prof. psychology, U. of K., Lawrence, Kan.
*Brubaker, H. W., Ph. D., 1929, prof. chemistry, K. S. C., Manhattan, Kan.
*Bryson, Harry R., M. S., 1933, asst. prof. entomology, K. S. C., Manhattan, Kan.
*Burt, Charles E., Ph. D., 1932, prof. biology, Southwestern Col., Winfield, Kan.
*Burt, Roy A., B. S., 1934, geologist, 56th and Shawnee Mission Rd., Kansas City, Kan.
*Busenbark, Ray, 1935, Jr. Col., Kansas City, Kan.
*Cady, Ruth, A. B., 1935, grad. student, bacteriology, U. of K., Lawrence, Kan.
Caldwell, J. Marvin, A. B., 1934, grad. student, U. of K., Lawrence, Kan.
*Call, L. E., M. S., 1922, dean, Div. Agric., dir. Agric. Exp. Sta., K. S. C., Manhattan, Kan.
*Campbell, Marion I., M. S., 1929, Topeka State Hospital, Topeka, Kan.
*Carlson, Hjalmar E., M. D., 1932, asst. surgery, U. of K. Med. Sch., 3944 Rainbow Blvd., Kansas City, Kan.
*Carpenter, A. C., 1929, president, Lesh Oil Co., Ottawa, Kan.
*Carpenter, Pearl I., M. A., 1935, instr. biology, Liberty Memorial H. S., Lawrence, Kan.
*Caruthers, Bertram, A. B., 1935, Jackson, Tenn.
*Casey, Margaret Tabor, Ward Nat. Hist. Estb., Rochester, N. Y.
*Chapin, Ernest K., M. S., 1934, assoc. prof. physics, K. S. C., Manhattan, Kan.
*Chance, Sylvester, A. B., 1932, physiology, Wichita H. S. East, Wichita, Kan.
Chogill, Harold S., A. M., 1934, instr. physics, Jr. Col., Garden City, Kan.
*Coco, Russell M., M. S., 1932, instr. H. S., Bordelonville, La.
*Cotton, Richard T., 1935, senior entomologist, U. S. D. A., Manhattan, Kan.
*Cowan, Edwina, Ph. D., 1929, dir. Wichita Child Res. Lab. Friends Univ., Wichita, Kan.
*Crain, Frank T., 1935, 3743 Eaton St., Kansas City, Kan.
*Crow, H. Ernest, Ph. D., 1926, prof. biology, Friends Univ., Wichita, Kan.
*Crum, L. A., A. B., 1935, geologist, Univ., Wichita, Kan.
*Daniels, Chas. M., A. B., 1934, Univ. Wichita, Wichita, Kan.
*Davidson, Arthur W., Ph. D., 1927, assoc. prof. chemistry, U. of K., Lawrence, Kan.
*Davis, Rex H. A., A. M., 1931, H. S., Atchison, Kan.
*Dean, George A., M. S., 1903, 1912, head Dept. Entomology, K. S. C., Manhattan, Kan.
*Dellett, Fred V., B. S., 1931, Pawnee Rock, Kan.
*Denio, Elgin A., M. S., 1931, Greeley, Kan.
*Dill, Robert L., 1934, student botany, U. of K., Lawrence, Kan.
*Dobrovolny, Chas. G., M. S., 1930, Zoölogy, Univ. of Mich., Ann Arbor, Mich.

*Dobrovolny, Mrs. Marjorie Prikett, M. S., 1930, dept. zoölogy, Univ. of Mich., Ann Arbor, Mich.
*Doell, J. H., A. B., 1926, prof. biology, Bethel Col., Newton, Kan.
*Doubt, Sarah L., Ph. D., 1935, prof. botany, Washburn Col., Topeka, Kan.
*Doudna, Wilbur, A. B., 1935, principal grade school, Richmond, Kan.
*Douglass, J. R., M. S., 1928, assoc. entomologist, U. S. B. Ent. & P. Q., Twin Falls, Idaho.
*Downs, Allen, 1935, student, K. S. T. C., Emporia, Kan.
*Downs, Cora M., Ph. D., 1935, assoc. prof. bacteriology, U. of K., Lawrence, Kan.
*Drake, J. P., M. A., 1930, prof. physics, K. S. T. C., Emporia, Kan.
*Dresher, C. H., 1930, science, Jr. H. S., McPherson, Kan.
*Duerksen, Harold, 1935, student, U. of Wichita, Wichita, Kan.
*Duley, F. L., Ph. D., 1929, U. S. D. I., Mankato, Kan.
Dunkle, David H., 1934, student zoölogy, U. of K., Lawrence, Kan.
Elbl, Ashley, A. B., 1934, asst. chemistry, Sterling Col., Sterling, Kan.
*Ellis, Ralph, 1935, 2420 Ridge Road, Berkeley, Cal.
*Emery, W. T., M. A., 1928, asst. entomologist, U. S. D. A., 128 S. Minneapolis, Wichita, Kan.
Enberg, L. A., 1934, asst. chemistry, McPherson Col., McPherson, Kan.
Eppley, A. G., 1934, Marysville, Pa.
*Everhardy, Louise H., M. A., 1931, assoc. prof. art, K. S. C., Manhattan, Kan.
*Evers, Robert A., B. S., 1931, 642 Payson avenue, Quincy, Ill.
*Falls, Olive, M. S., 1933, E. L. Bruce Co., Memphis, Tenn.
*Farber, Louis M., 1935, plant engineer, Chevrolet plant, Kansas City, Mo.
*Farrell, F. D., B. S., 1924, president, K. S. C., Manhattan, Kan.
*Filinger, Geo. A., Ph. D., 1932, asst. prof. pomology, K. S. C., Manhattan, Kan.
*Fletcher, Worth A., Ph. D., 1928, prof. chemistry, Univ. Wichita, Wichita, Kan.
*Flora, S. D., 1934, meteorologist, U. S. Weather Bureau, Topeka, Kan.
*Floyd, Willis W., Ph. D., 1932, prof. chemistry, Ottawa Univ., Ottawa, Kan.
*Ford, Helen, Ph. D., 1928, head, Dept. Child Welfare and Euthenics, K. S. C., Manhattan, Kan.
*Foster, Mark A., M. S., 1931, Rockefeller Fellow in Endocrinology, U. of Wis., Madison, Wis.
*Fraser, S. V., 1931, catholic priest, Aurora, Kan.
*Furbay, J. H., Ph. D., 1934, prof. biology, C. of E., Emporia, Kan.
*Gates, F. C., Ph. D., 1922, prof. botany, K. S. C., Manhattan, Kan.
*Geer, Harriet A., M. A., 1935, grad. student, U. of K., Lawrence, Kan.
*Gentry, Adrian N., B. S., 1933, grad. student, zoölogy, U. of K., 1206 Tennessee St., Lawrence, Kan.
*Gier, L. J., M. S., 1931, Campbell Col., Buies Creek, N. C.
*Giersch, Sister Crescentia, M. S., 1934, instr. Biology, Marymount Col., Salina, Kan.
Gill, Geo. L., 1934, student, Sterling Col., Sterling, Kan.
*Gillum, Isabelle, M. S., 1935, Food Econ. & Nutr., K. S. C., Manhattan, Kan.
*Glover, J. A., A. B., 1934, chemistry, H. S. North, Wichita, Kan.
*Goldsmith, William M., Ph. D., 1924, prof. biology, Univ. Wichita, Wichita, Kan.
*Gottlieb, Selma, Ph. D., 1931, chemist, Water Lab., U. of K., Lawrence, Kan.
*Grimes, Waldo E., Ph. D., 1925, head, Dept. Agric. Econ. K. S. C., Manhattan, Kan.
*Griner, A. J., 1931, dealer in scientific instruments, 417 E. Thirteenth street, Kansas City, Mo.
*Griswold, Sylvia M., Ph. D., 1935, prof. biology, St. Marys Col., Leavenworth, Kan.
*Groeber, Margarett, A. B., 1935, instr. biology, H. S., Topeka, Kan.
*Haggart, Margaret H., M. A., 1932, head Home Economics Dept., F. H. K. S. C., Hays, Kan.
*Hall, H. H., Ph. D., 1934, prof. biology, K. S. T. C., Pittsburg, Kan.
*Hall, J. Lowe, Ph. D., 1929, asst. prof. chemistry, K. S. C., Manhattan, Kan.
*Hallsted, A. L., 1929, Hays, Kan.
*Hancin, John, 1931, 114½ S. Fifth street, Salina, Kan.
*Haney, Paul, 1935, St. Bd. Health, 739 Ohio St., Lawrence, Kan.
*Harbaugh, M. J., M. S., 1930, asst. prof. zoölogy, K. S. C., Manhattan, Kan.
Harms, Anna E., M. A., 1932, prof. biology, Tabor Col., Hillsboro, Kan.
*Harris, C. L., Ph. M., 1928, attorney at law, Box 1088, El Dorado, Kan.
*Hartel, Lawrence W., M. S., 1930, asst. prof. physics, K. S. C., Manhattan, Kan.
*Hartley, Clara, M. A., 1931, Baker Univ., Baldwin, Kan.
*Hartman, Haugh E., B. S., 1928, asst. eng., 537 S. Chautauqua avenue, Wichita, Kan.

*Harvard University Library, 1930, Cambridge, Mass.
*Hecht, Edith Cobden, 1932, Cape Girardeau, Mo.
*Henry, Edwin R., Ph. D., 1927, instr. psychology, New York Univ. Heights, New York, N. Y.
*Herbertson, James E., 1934, student, biol., Friend's Univ., Wichita, Kan.
*Herrick, Earl H., Ph. D., 1927, 1935, assoc. prof. zoölogy, K. S. C., Manhattan, Kan.
*Hershey, J. Willard, Ph. D., 1920, prof. chemistry, McPherson Col., McPherson, Kan.
*Hertzler, Arthur E., M. D., Ph. D., 1928, prof. surgery, U. of K. Med. Sch., head surgeon Halstead Hosp., Halstead, Kan.
*Hibbard, Claude W., M. A., 1933, student, Dept. Paleontology, Univ. Museum, Lawrence, Kan.
*Higbie, Water, 1934, chemist, Paper Makers Chemical Corp., Kalamazoo, Mich.
*Hodge, Harold C., Ph. D., 1931, School of Medicine, Univ. Rochester, Rochester, N. Y.
*Hoffman, William E., M. A., 1920, dir. Lignan Nat. Hist. Survey and Museum, Lignan Univ., Canton, China.
*Hof, Elmer A., 1935, student, U. of K., Lawrence, Kan.
*Horr, W. H., A. M., 1933, asst. prof. botany, U. of K., Lawrence, Kan.
*Horton, John R., B. S., 1922, entomologist, U. S. D. A., 128 S. Minnesota avenue, Wichita, Kan.
*Hoyle, William Luther, 1934, student entomology, K. S. C., Manhattan, Kan.
*Hudiburg, Leo E., M. S., 1931, asst. prof. physics, K. S. C., Manhattan, Kan.
*Hughes, J. S., Ph. D., 1926, 1929, prof. chemistry, K. S. C., Manhattan, Kan.
Hughes, Raymond H., B. S., 1934, grad. stud., Univ. of Chicago, Chicago, Ill.
Humphrey, Irwin, M. S., 1912, research chemist, Hercules Pwd. Co., Wilmington, Del.
*Hungerford, H. B., Ph. D., 1920, head Dept. Entomology, U. of K., Lawrence, Kan.
*Hutchison, Frances S., M. S., 1932, instr. biology, H. S. and Jr. Col., El Dorado, Kan.
*Ibsen, Herman L., Ph. D., 1922, prof. genetics, Animal Husb. Dept., K. S. C., Manhattan, Kan.
*Irvin, Charles Verner, B. S., 1934, science and math., H. S., St. John, Kan.
*Jackson, D. C. Jr., 1933, Lewis Institute, 1951 W. Madison St., Chicago, Ill.
*Jardine, W. M., Ph. D., 1919, president Univ. Wichita, Wichita, Kan.
Jenkins, Maynard, 1934, 313 W. Adams, Pittsburg, Kan.
*Jewell, Minna E., Ph. D., 1925, prof. zoölogy, Thornton Twp. Jr. Col., Harvey, Ill.
*Jewett, J. M., A. M., 1933, instr. geology, Univ. Wichita, Wichita, Kan.
Johnson, Ethel M., 1934, student biology, Bethany Col., Lindsborg, Kan.
Johnson, George E., Ph. D., 1925, prof. zoölogy and expt. sta. mammalogist, K. S. C., Manhattan, Kan. (Deceased.)
*Johnston, C. O., M. S., 1928, assoc. plant pathologist, K. S. C., Manhattan, Kan.
*Jones, Elmer T., A. M., 1932, asst. entomologist, Bur. Entomology, 1204 Fremont, Manhattan, Kan.
*Jones, Lloyd Waldo, 1935, student, K. S. T. C., Emporia, Kan.
*Junction City Jr.-Sr. H. S. Science Club, 1934, H. R. Callahan, Sponsor, Junction City, Kan.
*Justin, Margaret M., Ph. D., 1925, dean, Div. Home Economics, K. S. C., Manhattan, Kan.
*Kansas City Public Library, 1930, Kansas City, Mo.
*Kaufman, Clemens M., 1935, student, Bethel Col., Newton, Kan.
*Kaufman, Clinton, A. B., 1934, inst. science, H. S., Walton, Kan.
*Kelly, E. G., Ph. D., 1935, prof. extension, K. S. C., Manhattan, Kan.
*Kelly, Geo. A., Ph. D., 1932, instr. psychology, F. H. K. S. C., Hays, Kan.
*Kester, F. E., Ph. D., 1929, prof. physics, U. of K., Lawrence, Kan.
*Kingman, Robert H., M. S., 1935, zoölogy, Washburn Col., Topeka, Kan.
*Kingsley, Eunice L., M. S., 1933, instr. botany, K. S. C., Manhattan, Kan.
*Kinney, Edward D., B. S., 1930, assoc. prof. and head Dept. Chemical Engineering, U. of K. Lawrence, Kan.
Kirkpatrick, Ernest L., 1934, student, K. S. T. C., Emporia, Kan.
Kitchen, Mary E., B. S., 1924, Box 2067, Univ. Sta., Enid, Okla.
*Kramer, Martha M., Ph. D., 1925, 1932, prof. food econ. and nutrition, K. S. C., Manhattan, Kan.
*Kunerth, Bernice, M. S., 1933, tech. food economics and nutrition, K. S. C., Manhattan, Kan.
*Lahr, E. L., M. S., 1932, Carnegie Inst., Cold Spring Harbor, L. I., N. Y.
*Landes, Kenneth K., Ph. D., 1931, asst. state geologist, U. of K., Lawrence, Kan.
*Lane, H. Wallace, A. B., 1935, grad. student, bacteriology, U. of K., Lawrence, Kan.
*Larson, Mary E., A. M., 1925, asst. prof. zoölogy, U. of K., Lawrence, Kan.

*Latimer, Homer B., Ph. D., 1928, prof. anatomy, U. of K., Lawrence, Kan.
*Lawrence Jr. H. S. Nature Club, sponsor, Edith Beach, 1932, Lawrence, Kan.
Lawson, Paul B., Ph. D., 1919, prof. entomology, U. of K., Lawrence, Kan.
*Lee, Floyd B., A. M., 1933, dean, F. H. K. S. C., Hays, Kan.
*Leech, Amos, 1935, student, U. of K., Lawrence, Kan.
*Lefebvre, C. L., Ph. D., 1933, asst. prof. botany, K. S. C., Manhattan, Kan.
*Leist, Claude, M. A., 1929, assoc. prof. biology, K. S. T. C., Pittsburg, Kan.
*Liberty Memorial High School, Ben Franklin Club, 1935, sponsors, Robert E. Wood and C. B. Cunningham, Lawrence, Kan.
Lind, August A., M. S., 1934, teacher Jr. H. S., La Crosse, Kan.
*Lindley, E. H., Ph. D., LL .D., 1923, chancellor, U. of K., Lawrence, Kan.
*Lippert, A. B., 1935, Bison, Kan.
*Loewen, S. L., M. A., 1931, prof. biology, Sterling Col., Sterling, Kan.
*Long, W. S., Ph. D., 1929, head Chemistry Dept., Kansas Wesleyan, Salina, Kan.
*Lyon, Eric, M. S., 1926, assoc. prof. physics, K. S. C., Manhattan, Kan.
*Lyon, Jeanne, M. S., 1930, 1026 Bertrand, Manhattan, Kan.
*Ludwig, Sylvester T., A. M., 1934, pres. Bresee Col., Hutchinson, Kan.
Manhattan H. S. Science Club, 1932, sponsor, L. P. Elliott, Manhattan, Kan.
*Marlow, H. W., Ph. D., 1935, asst. prof. chemistry, K. S. C., Manhattan, Kan.
*Marten, E. A., Ph. D., 1931, assoc. prof. chem. and bacteriol., Univ. Wichita, Wichita, Kan.
Martinez, Carl J., M. S., 1933, grad. student, physics, K. S. C., Manhattan, Kan.
*Matthews, Wm. H., M. A., 1920, assoc. prof. physics, K. S. T. C., Pittsburg, Kan.
*Maxwell, Geo. W., M. S., 1929, asst. prof. physics, K. S. C., Manhattan, Kan.
*Mayberry, J. W., 1932, prof. chemistry, K. S. T. C., Emporia, Kan. (Deceased.)
*Mayberry, M. W., M. A., 1933, asst. instr. botany, U. of K., Lawrence, Kan.
*McCullough, A. W., A. B., 1934, student asst. zoölogy, U. of K., Lawrence, Kan.
*McDonald, Clinton C., Ph. D., 1928, prof. botany, Univ. Wichita, Wichita, Kan.
*McElray, Abigail, M. S., 1935, instr. biology, H. S., Topeka, Kan.
*McKinley, Lloyd, Ph. D., 1928, Univ. Wichita, Wichita, Kan.
*Melchers, Leo Edward, M. S., 1918, head Dept. Botany and Plant Path., K. S. C., Manhattan, Kan.
*Menninger, Karl A., M. D., 1919, physician, 3617 W. Sixth street, Topeka, Kan.
*Michener, John M., M. S., 1925, head Science Dept., H. S. East, Wichita, Kan.
*Miller, Edwin Cyrus, Ph. D., 1918, prof. botany, K. S. C., Manhattan, Kan.
*Miller, R. F., Ph. D., 1928, prof. physics, Col. Emporia, Emporia, Kan.
*Mitchell, U. G., Ph. D., 1931, prof. mathematics, U. of K., Lawrence, Kan.
*Mix, Arthur J., Ph. D., 1931, prof. botany, U. of K., Lawrence, Kan.
*Mohler, R. E., M. S., 1929, prof. biology, McPherson Col., McPherson, Kan.
*Moore, Flemming G., Ph. D., 1927, prof. physics, Washburn Col., Topeka, Kan.
*Moore, Raymond C., 1934, geology, U. of K., Lawrence, Kan.
Moran, Paul W., A. B., 1933, chemist, St. Nicholas Hotel, Duquoin, Ill.
*Morgan, William J., D. ès L., 1935, prof. phil. & social ethics, Washburn Col., Topeka, Kan.
*Morris, Mary Hope, M. S., 1929, Hutchinson Jr. Col., Hutchinson, Kan.
Murphy, Paul, Ph. D., 1933, asst. prof. psychology, K. S. T. C., Pittsburg, Kan.
*Nagge, Joseph W., Ph. D., 1935, instr., K. S. T. C., Emporia, Kan.
*Naismith, James, M. D., 1931, prof. physical education, U. of K., Lawrence, Kan.
*Nash, Bert A., Ph. D., 1930, assoc. prof. education, dir. Educational Clinic, U. of K., Lawrence, Kan.
*Neher, S. J., M. S., 1930, instr. botany, H. S., Portis, Kan.
*Newman, Edwin B., A. M., 1930, psychology, 740 Riverside Drive, New York, N. Y.
*Nininger, H. H., A. M., 1921, 1955 Fairfax street, Denver, Colo.
*Obee, Donald J., A. B., 1933, asst. botany, U. of K., Lawrence, Kan.
*O'Connor, Maurine, 1935, student, Mt. St. Scholastica, Atchison, Kan.
*Old, Edna, A. M., 1935, asst. instr., U. of K., Lawrence, Kan.
Oman, A. E., M. F., 1928, Ricks Hall, State College, Raleigh, N. C. (Deceased.)
*Omer, Guy C., Jr., 1935, Haskell Inst., Lawrence, Kan.
*Oncley, Lawrence, M. S., 1933, head Physical Sciences & Math., Southwestern Col., Winfield, Kan.
*Oregon State Agric. Col. Library, Corvallis, Ore.
*Owen, F. T., Ph. D., 1931, prof. chemistry, Col. Emporia, Emporia, Kan.
*Painter, Reginald, Ph. D., 1927, asst. prof. entomology, K. S. C., Manhattan, Kan.

*Parker, John H., Ph. D., 1918, prof. crop imp., Dept. Agron., K. S. C., Manhattan, Kan.
*Parks, W. B., Ph. D., 1931, prof. chemistry, K. S. T. C., Pittsburg, Kan.
*Payne, Sister Anthony, A. M., 1930, Mount St. Scholastica, Atchison, Kan.
*Perkins, Alfred T., Ph. D., 1925, 1929, 1931, asst. prof. chemistry, K. S. C., Manhattan, Kan.
*Perrine, Irving, Ph. D., 1921, oil operator, geologist, 1619-21 Petroleum Bldg., Oklahoma City, Okla.
*Peterka, Harry, M. A., 1933, asst. instr. zoölogy, U. of K., Lawrence, Kan.
*Peterson, J. C., Ph. D., 1919, prof. education, K. S. C., Manhattan, Kan.
*Pittman, Martha S., Ph. D., 1925, 1931, prof. food econom. and nutrition, K. S. C., Manhattan, Kan.
*Portis High School, 1935, sponsor, S. J. Nehr, Portis, Kan.
*Portrum, Donald C., M. S., 1933, grad. student psychology, K. S. T. C., Pittsburg, Kan.
Pratt, Bertha M., B. A., 1932, asst., Wichita Child Res. Lab., Friends Univ., Wichita, Kan.
*Pratt, Ivan, M. S., 1935, grad. student zoölogy, Univ. Wisconsin, Madison, Wis.
*Preble, Norman A., 1935, student, U. of K., Lawrence, Kan.
*Pretz, Paschal H., M. S., 1930, prof. physics, St. Benedict's Col., Atchison, Kan.
*Pyle, C. B., Ph. D., head, psychology and philosophy, K. S. T. C., Pittsburg, Kan.
*Quinn, Dolores, 1935, 1710 A street, Lincoln, Neb.
*Rankin, Roy, M. A., 1919, chemistry and chairman Div. Sci., F. H. K. S. C., Hays, Kan.
*Rarick, C. E., 1935, pres. F. H. K. S. C., Hays, Kan.
*Rogers, Cornelius, 1935, student, Southwestern Col., Winfield, Kan.
*Rouse, J. E., M. S., 1928, prof. agric., F. H. K. S. C., Hays, Kan.
*Sanders, Ottys, A. B., 1934, Southwestern Biol. Sup. Co., P. O. Box 4084, Dallas, Tex.
*Sarracino, John, B. S., 1928, Box 295, Neodesha, Kan.
*Sauer, F. C., Ph. D., 1931, asst. prof. zoöl., Univ. of Wichita, Wichita, Kan.
*Schaefer, Helen I., 1935, 1220 Market street, Emporia, Kan.
*Schaffner, D. C., A. M., 1931, geology and botany, Col. Emporia, Emporia, Kan.
*Schoewe, Walter H., Ph. D., 1925, assoc. prof. geology, U. of K., Lawrence, Kan.
*Schovee, Joseph C., 1928, asst. eng. A. T. & S. F. R. R., 1235 Boswell avenue, Topeka, Kan.
*Schrammel, H. E., Ph. D., 1929, prof. psychology, K. S. T. C., Emporia, Kan.
*Schumann, Margaret, M. A., 1922, technician, Anatomy Dept., U. of K., Lawrence, Kan.
*Seaton, Roy A., M. S., 1928, dean, Div. Engineering, K. S. C., Manhattan, Kan.
*Shadd, Geo. C., 1921, dean, Engineering School, U. of K., Lawrence, Kan.
*Shawnee-Mission Rural H. S. Science Club, 1932, sponsor, Jas. C. Hawkins, sec., Arminta Smith, Merriam, Kan.
*Sherwood, Noble P., Ph. D., 1935, prof. bacteriology, U. of K., Lawrence, Kan.
*Sites, Blaine E., B. S., 1932, teacher physics and chemistry, H. S., Salina, Kan.
*Smith, Arlene, 1935, student, K. S. C., Manhattan, Kan.
Smith, Hobart M., M. S., 1932, grad. student, zoölogy, U. of K., Lawrence, Kan.
*Smith, R. C., Ph. D., 1921, prof. entomology, K. S. C., Manhattan, Kan.
*Smits, Benjamin L., Ph. D., 1930, assoc. food analyst, K. S. C., Manhattan, Kan.
*Snyder, Dorrice, A. B., 1935, asst. psychologist, child res. lab., Friends Univ., Wichita, Kan.
Snyder, Leon, 1934, student, Southwestern Col., 1621 E. Seventh street, Winfield, Kan.
Spann, Liza, M. A., 1933, Murray, Ky.
*Spencer, D. H., 1925, School of Pharmacy, U. of K., Lawrence, Kan.
*Sperry, Arthur B., B. S., 1917, 1922, prof. geology, K. S. C., Manhattan, Kan.
Staley, Kathryn M., M. S., 1934, asst. botany, U. of K., Lawrence, Kan.
*Stebbins, Florence M., M. S., 1933, asst. genetics, K. S. C., Manhattan, Kan.
*Stephenson, Lyle, 1932, 118 E. Tenth street, Kansas City, Mo.
*Sternberg, Chas. W., 1935, 603 Elm street, Hays, Kan.
*Sternberg, George F., M. S., (Hon.) 1928, field vertebrate paleontologist, F. H. K. S. C., Hays, Kan.
*Stieferman, Sister M. Aquinas, 1934, Sacred Heart Jr. Col., Sheridan and McCormic, Wichita, Kan.
Stiles, Elsa Horn, M. S., 1928, instr. botany, K. S. C., Manhattan, Kan.
*Stockard, Ruth, A. B., 1935, student, U. of K., Lawrence, Kan.
*Stoland, O. O., Ph. D., 1918, prof. physiology and pharmacology, U. of K., Lawrence, Kan.
*Stottlar, Arnold, B. S., 1935, grad. student, K. S. T. C., Emporia, Kan.
*Stouffer, E. B., Ph. D., 1929, dean, Grad. School, U. of K., Lawrence, Kan.
*Strickler, Paul M., M. A., 1935, 709 Mississippi street, Lawrence, Kan.

*Stroud, J. B., Ph. D., 1932, chm. Dept. Psychology and Philosophy, K. S. T. C., Emporia, Kan.
*Studt, Charles W., M. S., 1928, Sagamore Oil and Gas Co., Independence, Kan.
*Sutter, H. Mack, A. B., 1934, 511 Smythe, Wichita, Kan.
*Sutter, L. A., M. D., 1923, physician, 611 First National Bank Bldg., Wichita, Kan.
*Swanson, Arthur F., M. S., 1926, agronomist, Branch Exp. Sta., Hays, Kan.
*Swartz, Daphne Bell, M. A., 1935, U. of K., Lawrence, Kan.
*Talbott, W. A., Jr., 1935, Underhill Terminix Co., Wichita, Kan.
*Taft, Robert, Ph. D., 1923, 1929, assoc. prof. chemistry, U. of K., Lawrence, Kan.
Taggart, Kathryn, A. B., 1934, student, botany, U. of K., Lawrence, Kan.
*Taylor, Edward H., Ph. D., 1928, assoc. prof. zoölogy, U. of K., Lawrence, Kan.
*Taylor, Mary Fidelia, A. M., 1930, student, Univ. of Chicago, Chicago, Ill.
*Thomas, Lawrence C., Ph. D., 1932, head Biology Dept., Kansas Wesleyan Univ., Salina, Kan.
*Thompson, D. Ruth, M. A., 1928, prof. chemistry, Sterling Col., Sterling, Kan.
*Thompson, Rufus H., A. B., 1934, student botany, U. of K., Lawrence, Kan.
*Treece, E. Lee, Ph. D., 1929, assoc. prof. bacteriology, U. of K., Lawrence, Kan.
*Trent, J. A., M. A., 1934, asst. prof. biol., K. S. T. C., Pittsburg, Kan.
Triplett, Dorothy, Ph. D., 1931, assoc. prof. child welfare and euthenics, K. S. C., Manhattan, Kan.
*Underwood, H. G., Ph. D., 1935, asst. prof. chemistry, Bethany Col., Lindsborg, Kan.
Varnloff, Hazel, B. S., 1934, teacher biology, Bethany Col., Lindsborg, Kan.
*Voth, Arnold, 1932, teacher, Moundridge, Kan.
Wade, Wayne, 1934, student, Southwestern Col., R. R. 3, Winfield, Kan.
*Waring, Sister Mary Grace, Ph. D., 1932, head Science Dept., Marymount Col., Salina, Kan.
*Warner, Robert W., E. E., 1935, prof. elect. engr., U. of K., Lawrence, Kan.
*Way, P. Ben, B. Sc., 1932, teacher H. S., Wichita, Kan.
*Weber, Clement, 1928, catholic priest, Box 186, Selden, Kan.
*Weber, Louis R., Ph. D., 1929, head Physics Dept., Friends Univ., Wichita, Kan.
*Weeks, Elvira, Ph. D., 1927, asst. prof. chemistry, U. of K., Lawrence, Kan.
*Weidlein, Edward Ray, Sc. D., 1911, dir. Mellon Inst. Ind. Res., Pittsburgh, Pa.
*Wellman, Coyle, 1935, biology, Sterling Col., Sterling, Kan.
*Wells, J. Ralph, Ph. D., 1934, prof. biology, K. S. T. C., Pittsburg, Kan.
*Wichita City Library, 1932, Ruth E. Hammond, librarian, Wichita, Kan.
*Wichita H. S. East Chemistry Club, 1934, sponsor, Carl Barnhardt, Wichita, Kan.
Wichita, H. S. North Science Club, 1932, sponsor, J. A. Glover, president, Fred A. Hale, Wichita, Kan.
*Wilbur, Donald A., A. M., 1934, asst. prof. entomology, K. S. C., Manhattan, Kan.
*Williams, Chas. C., A. B., 1935, 2612 E. Waterman street, Wichita, Kan.
Wilson, Jack Turner, A. B., 1933, instr. chemistry, Emporia Col., Emporia, Kan.
*Wismer, C. A., M. S., 1933, Firestone Plantations Co., Monrovia, Liberia, W. Africa.
*Wismer, Nettie M., M. S., 1932, science teacher, Jr. H. S., Lawrence, Kan.
*Wolcott, Grace G., A. B., 1935, instr., 1149 Garfield street, Topeka, Kan.
*Wolfson, Chas., M. A., 1935, asst. zoölogy, U. of K., Lawrence,, Kan.
*Wood, Robert E., M. S., 1930, chemistry, H. S., Lawrence, Kan.
*Woodard, Parke, M. D., 1930, asst. prof. physiology, U. of K., Lawrence, Kan.
*Wooster, L. D., Ph. M., 1924, prof. zoölogy, F. H. K. S. C., Hays, Kan.
Wyman, Fred Jr., 1934, student, Col. Emporia, Emporia, Kan.
*Yoder, J. J., LL. D., 1926, prof. sociology, McPherson Col., McPherson, Kan.
*Young, H. D., 1935, assoc. chemist, U. S. D. A., 1204 Fremont, Manhattan, Kan.
*Zinszer, Harvey A., Ph. D., 1930, prof. physics and astronomy, F. H. K. S. C., Hays, Kan.
*Zinszer, Richard H., B. S., (Eng.), 1931, 422 W. Twelfth street, Hays, Kan.

SIXTY-SEVENTH ANNUAL MEETING

KANSAS ACADEMY OF SCIENCE

University of Kansas, Lawrence, Kan., March 28-30, 1935

OFFICERS OF THE ACADEMY

WM. H. MATTHEWS, Pittsburg....................President
E. A. MARTEN, Wichita....................First Vice-president
W. J. BAUMGARTNER, Lawrence....................Second Vice-president
G. E. JOHNSON, Manhattan....................Secretary
F. C. GATES, Manhattan....................Secretary, Pro Tempore
H. A. ZINSZER, Hays....................Treasurer

Chairmen of Sections

L. E. MELCHERS, Biology
H. R. BRYSON, Entomology
PAUL MURPHY, Psychology
L. ONCLEY, Chemistry
G. W. MAXWELL, Physics
HAZEL E. BRANCH, Junior Academy
C. E. BURT, Vice-chairman, Biology

Additional Members of the Executive Council

J. W. HERSHEY, McPherson
J. B. STROUD, Emporia
R. H. BEAMER, Lawrence

PROGRAM

THURSDAY, MARCH 28

8:20 p. m. "Glimpses of Germany," Dr. Ralph H. Major, Professor of Medicine, School of Medicine, University of Kansas. Auditorium on the second floor of Fraser Hall.

FRIDAY, MARCH 29

9:00 a. m. General papers, Engineering Building, Room 206.
1:00 p. m. Exhibits and demonstrations: Soil Erosion, Snow Hall, Room 221.
Fluorescent minerals, Engineering Bldg., near Room 206.
1:15 p. m. Junior Academy of Science, Engineering Building, Room 206.
1:30 p. m. Section Programs:
- a. Biology, Snow Hall.
  - 1a. Botany, Room 417.
  - 1b. Zoölogy, Room 101.
- b. Chemistry, Snow Hall, Room 501.
- c. Medical Science, Snow Hall, Room 206.
- d. Physics, Snow Hall, Room 502.
- e. Psychology, Snow Hall, Room 301.

6:00 p. m. Banquet, University Cafeteria, Memorial Union.
Toastmaster, Noble P. Sherwood.
Address of Welcome: Dr. E. H. Lindley, Chancellor of University of Kansas.
Presidential Address: "Scientific Development and Investigation in Southeast Kansas." W. H. Mathews, Kansas State Teachers College, Pittsburg, Kan.

8:15 p.m. Address: "Tree Rings and Climate in Relation to Ancient Civilizations of the Southwest," a lecture illustrated with lantern slides and motion pictures. Dr. A. E. Douglass, Tree Ring Laboratories, University of Arizona, University of Kansas Auditorium.

SATURDAY, MARCH 30

8:15 a.m. General papers and business, Engineering Building, Room 206.
10:00 a.m. Entomology papers. Snow Hall, Room 301.
12:00 noon Meeting of the new Executive Council.
1:30 p.m. Entomology papers, Snow Hall, Room 301.

PAPERS SUBMITTED FOR THE SIXTY-SEVENTH ANNUAL MEETING

GENERAL PAPERS

Friday, March 29, 9 a.m., Engineering Building, Room 206

1. Saving the Elm Trees in Lawrence. W. J. Baumgartner, U. of K.
2. A Comparison of Modern Photographic Materials. Oren Bingham and Robert Taft, U. of K.
3. Fluorescent Minerals. Oren Bingham, U. of K.
4. A Simple Experimental Method of Determining the Temperature of the Sun. C. V. Kent, U. of K.
5. Some Notable Kansas Trees (Notes for 1935). Frank Agrelius and Helen Schaefer, K. S. T. C., Emporia.
6. Water Resources of Johnson County During the Drouth of 1934. Chas. Williams and John M. Jewett, U. of W.
7. Kansas Botanical Notes, 1934. F. C. Gates, K. S. C.
8. Notes on the Effects of Drouth on Animal Population in Western Kansas. L. D. Wooster, F. H. K. S. C.
9. *Sclerotium delphinii*, a Pathogenic Fungus New to Kansas. Donald J. Obee, U. of K.
10. The Origin and Movement of Tornadoes. John T. Copley, Olathe, Kan.
11. Soil Blowing in Kansas. F. L. Duley, U. S. D. I., Mankato.
12. The Effects of Synthetic Atmospheres of Nitrous Oxide and Oxygen Upon Animal Life. J. Willard Hershey, McPherson College.
13. The Length of Animal Life Without Water. J. Willard Hershey, McPherson College.
14. Amphibian Tracks in Chase County, Kansas, Rocks. L. C. Wooster, Emporia.

PAPERS READ BY TITLE

1. Some Myths and Traditions of the Hoh and Quillayute Indians. Albert B. Reagan, Provo, Utah.
2. Some Measurements at the Sun City Natural Bridge. J. M. Jewett, U. of W.
3. The Origin and Development of the Crop in the Chick. M. W. Mayberry, U. of K.
4. Flora of Sedgwick County, Kan as. Sister M. Aquinas, Sacred Heart Jr. College, Wichita.
5. Plants of Saline County, Kansas. John Hancin, Salina, Kansas.
6. The Preparation of Some New Azo Derivatives of Guaiacol, II. Raymond C. Clapp and Worth A. Fletcher, U. of W.
7. Studies of Extracts of Residual Ovaries. H. W. Marlow, K. S. C.
8. The Reaction of the Trees of Manhattan, Kansas, to the Drouth of 1934. Elsa Horn Stiles and L. E. Melchers, K. S. C.

BOTANY PAPERS

Friday, March 29, 1:30 p.m., Snow Hall, Room 417
L. E. MELCHERS, Manhattan, Chairman
W. C. STEVENS, Lawrence, Acting Chairman

1. A Fungus Affecting Stands of Alfalfa Seedlings on Fallow Soil. C. L. Lefebvre, C. O. Grandfield and W. H. Metzger, K. S. C.
2. Mycological Notes, I. C. L. Lefebvre and C. O. Johnston, K. S. C.
3. Notes on a Rare Alga: Basicladia. Edna Old, U. of K.
4. Morphology and Habit of *Androstephium caeruleum*. W. C. Stevens, U. of K.

5. Microscopic Anatomy of *Mollugo verticillata*. Sister M. Anthony Payne, O. S. B., U. of K.
6. Comparative Anatomy of Some Species of Populus. Daphne Bell Swartz, U. of K.
7. Structural Adaptation to Drouth of *Androcera rostrata*. Ruth Stockard, U. of K.
8. Morphology and Physiology of the Underground Parts of *Helianthus grosseserratus*. Amos Leech, U. of K.
9. Floral Calendar for Douglas County and Vicinity. Florence Briscoe, U. of K.
10. The Endodermis of Some Species of Carduaceae. M. W. Mayberry, U. of K.
11. Assimilation of Strychnine by *Aspergillus niger*. James C. Bates, U. of K.
12. Some Anatomical Features of *Euphorbia hyssopifolia* in Relation to its Water Economy. Rufus Thompson, U. of K.

ZOOLOGY PAPERS

Friday, March 29, 1:30 p. m., Snow Hall, Room 101
C. E. Burt, Winfield, Chairman

1. A New Nematode From the Cat. J. E. Ackert and E. E. Leasure, K. S. C.
2. Resistant Strains of White Leghorn Chickens to Parasitism. Ivan Pratt and J. E. Ackert, K. S. C.
3. The Beet Webworm Outbreak in Kansas in 1934. Donald A. Wilbur, K. S. C.
4. New Species of Earthworms for Kansas. Charles R. Gilbert.
5. The Chloropidae (Diptera) of Kansas. Curtis W. Sabrosky, K. S. C.
6. Pseudopodia Formation in Germ Cells of Grasshoppers. W. J. Baumgartner, U. of K.
7. Notes on the Behavior of a Small Amoeba, Genus *Naegleria*. A. W. McCullough, U. of K.
8. Cestode Anomalies. C. G. Dobrovolny and M. Prickett Dobrovolny, K. S. C.
9. A Key to the Lizards of the United States and Canada. Charles E. Burt, Southwestern U.
10. Proposed Nomenclatorial Changes in the Genus Eumeces. Edward H. Taylor, U. of K.
11. Notes on Western Australian Amphibians. Edward H. Taylor, U. of K.
12. The Reptilian Fauna of Sonora, Siniloa and Nayarit. Edward H. Taylor, U. of K.
13. Notes on Lizards of the Torquatus Group of the Genus *Sceloporus*, With Descriptions of New Species. Hobart M. Smith.
14. Some Observations on the Development of the Teeth in the Guinea Pig, *Cavia cobaya*. Mary T. Harman and Arlene Smith, K. S. C.
15. "Parthenogenesis" in the Ovaries of Guinea Pigs. Mary T. Harman, K. S. C.
16. Some Helminth Parasites of Silphids and Other Insects. Chas. Dobrovolny, K. S. C.
17. Notes on *Tamias striatus lysteri* (Rich.) in New Hampshire. Norman A. Preble, U. of K.
18. The Occurrence of *Phynosoma coronatum frontale* in Montana. M. J. Harbaugh, K. S. C.

CHEMISTRY

Friday, March 29, 1:30 p. m., Snow Hall, Room 501
L. Oncley, Winfield, Chairman

1. Studies on Two Kansas Oil Wells: Mineralogy of the Formations and Chemical Nature of the Waters Encountered. L. A. Crum, K. E. R. C., Wichita, Kan., and Selma Gottlieb, Water Laboratory, U. of K.
2. A Study of the Mechanism of the Effect of Chlorine on the Biochemical Oxygen Demand. Frank T. Crain, U. of K., and Selma Gottlieb, Water Laboratory, U. of K.
3. Activated Carbon in Water Treatment. Paul D. Haney, Water Laboratory, U. of K.
4. Base Exchange in Soils. Alfred T. Perkins and H. H. King, K. S. C.
5. Assimilation of Phosphorus From Various Treated Soils. Alfred T. Perkins and H. H. King, K. S. C.
6. Vapor Pressure Measurements as a Means of Determining Activity Coefficients of Strong Electrolytes. L. E. Blackman, Emporia.
7. The Electro-deposition of Nickel in the Presence of Gum Arabic. C. F. Galloup and Robert Taft, U. of K.
8. A Physico-chemical Study of the System Thallous Formate-water. Lee Horsley and Robert Taft, U. of K.
9. Recent Developments in the Chemistry of Hormones. H. W. Marlow, K. S. C.
10. The Ternary System—Silver Nitrate, Ammonium Nitrate, Acetic Acid. Harriet Geer and A. W. Davidson, U. of K.
11. A New Method of Preparing Certain Anhydrous Acetates. Myrl R. Adams and A. W. Davidson, U. of K.
12. The Order of Organic Radicals. W. W. Floyd and R. Q. Brewster, U. of K.
13. Micro-weighing on an Analytical Balance. C. H. Whitnah, K. S. C.

14. Spectrometric Determination of Phosphorus on Soil Extracts. H. T. McGehee, K. S. C.
15. A Study of Oil-well Brine Disposal. Earnest Boyce, State Board of Health.

MEDICAL SCIENCE PAPERS

Friday, March 29, 1:30 p. m., Snow Hall, Room 206
PARKE WOODARD, Lawrence, Chairman

1. A Quantitative Study of the Skeletons of 208 Skunks (*Mephitis mesomelas avia*). H. B. Latimer and Richard H. Greer, U. of K.
2. Some Measurements of 104 Cats. H. B. Latimer and Frank C. Melone, U. of K.
3. The Growth of the Digestive System of the Fetal Cat. H. B. Latimer, U. of K.
4. a. Mitosis in the Neural Tube. F. C. Sauer, U. of W.
   b. A Method of Stereoscopic Reconstruction. (Demonstration.)
5. An Anomalous Circulation in the Dog. E. R. Lucas and O. O. Stoland, U. of K.
6. The Effect of Various Drugs on Coronary Circulation. O. O. Stoland, U. of K.
7. Studies on the Potency of *Latrodectes mactans* (black widow) Toxin. H. Wallace Lane, U. of K.
8. Preliminary Report Upon a New Organism, *Alcaligenes pseudoabortus*. Noble P. Sherwood, U. of K.
9. Antigenic Studies Upon the Genus *Pasteurella*. Glenn C. Bond and Cora M. Downs, U. of K.
10. Observations on the Fluorescence of Animal Tissues Under Ultra-violet Radiation. Ruth Cady, U. of K.
11. A Preliminary Study of the Vitamin-A Content of Milk and Colostrum. Bernice L. Kunerth, M. M. Kramer, and W. H. Riddell, K. S. C.
12. Some Effects of Experimental Diets Upon the Vitamin C Content of Organs of the Guinea Pig (*Cavia cobaya*). Isabelle Gillum and M. M. Kramer, K. S. C.
13. Notes on the Results of Feeding Nicotine to Albino Rats. Hazel E. Branch, Wichita, Kan.
14. Blood Picture Studies of Rabbits Subjected to Tobacco and Other Smokes. Mary Garlock, K. S. T. C., Pittsburg.

PHYSICS PAPERS

Friday, March 29, 1:30 p. m., Snow Hall, Room 502
G. W. MAXWELL, Manhattan, Chairman

1. Variations in the Velocity of Light. Guy C. Omer, Jr., and Jas. L. Lawson, U. of K.
2. Earth Resistivity as Affected by the Presence of Ground Water. R. W. Warner, U. of K.
3. A Missing Principle in Mechanics? E. K. Chapin, K. S. C.
4. A High-voltage Electrostatic Generator—Van de Graaf Type. D. C. Jackson and L. M. Farber, U. of K.
5. Non-elastic Collision Cross-sections for Slow Neutrons. L. H. Horsley, U. of K.
6. Processes Inverse to the Radio-active-decay. R. L. Dolecek, U. of K.
7. Systematics of the Light Isotopes. P. M. Strickler, U. of K.
8. Anomalous Reversal of Silver Nitrate Film by Continued Exposure to Radiation. Karl Martinez, K. S. C.
9. The Whittaker Quantum Mechanism. F. E. Kester, U. of K.
10. A Wave Picture of the Hydrogen Atom. C. V. Kent, U. of K.
11. A Differential Equation for Nuclear Wave Motion. E. R. Lyon, K. S. C.
12. Notes on Resonance of Spherical Shells. E. V. Floyd, K. S. C.
13. A Simple Method of Color Matching. Richard H. Zinszer, Indiana U.
14. Extended Use of the Spectrophotometer. Richard H. Zinszer, Indiana U.

PSYCHOLOGY PAPERS

Friday, March 29, 1:30 p. m., Snow Hall, Room 301
PAUL MURPHY, Pittsburg, Chairman

(Kansas Psychological Association: P. G. Murphy, president: J. A. Glaze secretary)

1. Relationship Between a Reading Test and Scholastic Marks of Freshmen at the University of Kansas. Nicholas D. Rizzo, U. of K.
2. The Use of Differential Mental Tests in Diagnosing Handicapped Children. Dorrice Snyder, Friends U.
3. Person as a Psychological Concept. C. B. Pyle, K. S. T. C., Pittsburg.
4. Retroactive Inhibition and the Transfer Theory, Joseph W. Nagge, K. S. T. C., Emporia.
5. The Effect of College Courses on Individual Differences. H. B. Reed, F. H. K. S. C.

6. The Mental Hygiene Needs of Kansas. B. A. Nash, U. of K.
7. The Status of Psychology in the Secondary Schools of Kansas. Roy Douglass, Havana, Kansas, and J. A. Glaze, K. S. T. C., Pittsburg.
8. Inheritance of "Nervous" Defects in Guinea Pigs. Heman L. Isben, K. S. C.
9. The Dynamics of Spiral Movement in Man. Robert L. Brigden, U. of K.

JUNIOR ACADEMY OF SCIENCE PROGRAM

Friday, March 29, 1:15 p.m., Engineering Building, Room 206

MAURICE RANSOM, Wichita, Chairman

(Junior Academy of Science: Hazel E. Branch, Wichita, chairman of the Academy's committee sponsoring Junior Academy; Maurice Ransom, Wichita High School East, president; Dan LaSchelle, Junction City Junior-Senior High School, secretary).

1. Liberty Memorial High School, Lawrence High School.
   Ben Franklin Club, Sponsors: C. B. Cunningham, R. E. Wood.
   a. Physics Group.
      "Tesla Coil and 250,000 Volts." Alex Mitchell and Marshal Goerill.
   b. Chemistry Group.
      "Dry Ice." Hugh Magruder and Moriana Cunningham.
2. Lawrence Junior High School, Lawrence, Kan.
   Lawrence Nature Study Club, Sponsor, Miss Edith Beach.
   Paramecia Studies, Bill Collins.
   A Collection of Cacti, Maurice Jackson.
   Chemistry as a Hobby. Edwin Price.
   A Tin Can Slide Machine. Harold Leffman.
3. Shawnee Mission Rural High School, Merriam, Kan.
   Science Club "The Retorts." Sponsor, Jas. C. Hawkins.
   Exhibition of mounted butterflies (Kansas).
   Chemical Demonstration.
4. Wichita High School East, Wichita, Kan.
   Chemistry Club Sponsor, J. A. Brownlee.
   A Gas Generator Apparatus.
   A Playlet.
5. Introduction of New Clubs. Wm. A. Matthews, President Kansas Academy of Science.
6. Business: Election of Officers. Report of Judges, Announcements, Adjournment.

GENERAL PAPERS AND BUSINESS

Saturday, March 30, 8:15 a.m., Engineering Building, Room 206

1. The Fluctuation of the Water-table in the Glaciated Portion of Kansas. Walter H. Schoewe, U. of K.
2. Law of Competency of Streams Misstated. Walter H. Schoewe, U. of K.
3. The Effect of Antuitrin-S Injections into Ground Squirrels. Burton L. Baker, K. S. C.
4. The Fourth Annual Insect Summary of Kansas. Roger C. Smith and E. G. Kelly, Manhattan, Kan.
5. Some Problems of Sedimentation Observed in the Bronson Group of the Kansas Pennsylvanian, J. M. Jewett, U. of W.
6. The Birds of Southeastern Kansas, With Migration Dates. Harry H. Hall, K. S. T. C., Pittsburg.
7. The Water Supply of the Upper Neosho River Basin. Lyman C. Wooster, Emporia.
8. The Kansas Mineral Industry During the Depression. Kenneth K. Landes, Lawrence, Kan.
9. Some Effects of Experimental Diets Upon Reproduction and Growth of the Guinea Pig (*Cavia cobaya*). Mary T. Harman and Isabelle Gillum, K. S. C.
10. Chromosome Studies. Edith Beach, Lawrence High School.
11. Chemistry of the Vitamins. J. S. Hughes, K. S. C.
12. Chondrocranium of *Cryptobranchus alleghenienis* Daubin. Hazel E. Branch.

ENTOMOLOGY PAPERS

Saturday, March 30, 10:00 a.m., and 1:30 p.m., Snow Hall, Room 417

H. R. BRYSON, Manhattan, Chairman

(Kansas Entomological Society, 11th annual meeting: H. R. Bryson, Manhattan, president; D. B. Whelan, Lincoln, Neb., vice-president; R. L. Parker, Manhattan, secretary-treasurer, Business meeting at 10 a.m. Papers (1-6) at 11 a.m. and (7-24) at 1:30 p.m).

1. Growth Rates Among Insects. L. C. Woodruff, U. of K.
2. Regeneration in the Cockroach. L. C. Woodruff, U. of K.
3. The Genus Anthracophaga in North America (Diptera, Chloropidae). Curtis W. Sabrosky, K. S. C.

4. A Proposed Classification of the Nearctic Stratiomyinae (Diptera). Maurice James, Fort Collins, Colorado.
5. The Families of the Fulgoroidea. Kathleen Doering, U. of K.
6. The Genus *Bacillometra*. H. B. Hungerford, U. of K.
7. The Alconeura of the United States. Melvin Griffith, U. of K.
8. *Achalarus lycidas* Abb. & Sm. (Lepidoptera, Hesperidae) New to Kansas. Wm. D. Field, U. of K.
9. Notes in Regard to the Redbud Leaf Folder, *Gelechia cercerisella* Cham. (Lepidoptera, Gelechiidae). R. L. Parker, K. S. C.
10. Suggestions for Revision of Orthopteroid morphology. Philip Leverault, U. of K.
11. Studies on the Taxonomy and External Morphology of Grasshopper Eggs. R. C. Bushland, K. S. C.
12. Some Problems in Transporting Insects to Foreign Countries. Sam G. Kelly, K. S. C.
13. Observations on Termites in the Great Plains Region. Olive Falls, K. S. C.
14. Motschulsky's Types of North American Stenelmis (Coleoptera). Milton Sanderson, U. of K.
15. A Preliminary Report on the Study of the Genus Listronotus (Coleoptera, Curculionidae). Lyman Henderson, U. of K.
16. Some Quantitative Effects of the Extremes of the Summer of 1934 Upon the Insect Population of Grasses. D. A. Wilbur, K. S. C.
17. Creosote Versus Other Chemical Repellents for Use Against the Chinch Bug. H. R. Bryson, K. S. C.
18. Certain Arthropods of Schofield Barracks, Hawaii. Thompson Lawrence, U. of K.
19. Study of the Genus Abedus. Joe Hidalgo, U. of K.
20. Eradication of Injurious Plant Pests by Bureau of Entomology and Plant Quarantine and Florida Plant Board in Florida. Geo. A. Dean, K. S. C.
21. Technique for Studying Tabanid Biologies. H. H. Schwardt, U. of Ark.
22. Variations in the Seasonal History of the Colorado Potato Beetle. Dwight Isely, U. of Ark.
23. Possibilities and Limitations of Forecasting Insect Occurrence. Dwight Isely, U. of Ark.
24. Notes on the Biologies of Nut Weevils. Otto Kumpe and Dwight Isely, U. of Ark.

Minutes of the Sixty-seventh Annual Meeting

The sixty-seventh annual meeting of the Academy was called to order at 9:10 a.m., March 29, 1935, in Fraser Hall, University of Kansas, Lawrence, by President Wm. H. Matthews. At about 11 a.m., a short business session was held, in which the following additional committee was appointed:

Auditing: L. D. Wooster, L. D. Havenhill.

An amendment to the constitution proposed.

The entire program of the Academy was presented as printed, with the exception that Medical Science papers were assembled from the various other scheduled sections.

The regular business meeting of the Academy was called to order by President Matthews at 9:15, March 30, in room 206, Engineering Building. The following report of the secretary was read and accepted:

REPORT OF THE SECRETARY

Following an operation in November, Professor Johnson was able to attend to the Academy business until in January, since which time, by action of the executive council, I have been acting as secretary. The present report follows closely that of previous reports.

PUBLICATION. One thousand bound and 200 separated copies of Volume 37 were received from the state printer in February, 1935. Copies were sent to members in good standing at that time, and 575 copies were delivered to the three supporting institutions.

New Members. The following persons have been elected to membership since the last meeting of the Academy:

Atchison (Mt. St. Scholastica): Maurine O'Connor.

Berkeley, Cal.: Ralph Ellis.

Bethel Col., Kan.: C. M. Kaufman.

Bison: Verne Lippert.

Emporia (K. S. T. C.): L. E. Blackman, A. G. Eppley 1934, Lloyd W. Jones, J. W. Nagge, Helen I. Schaefer, Arnold Stottlar.

Emporia (Col. of Emporia): J. H. Furbay 1934.

Hays (F. H. K. S. C.): C. E. Rarick.

Hays: Chas. W. Sternberg.

Kansas City, Kan.: F. T. Crain.

Kansas City, Kan. (Jr. Col.): Ray Busenbark.

Lawrence (Haskell Inst.): Guy C. Omer, Jr.

Lawrence (Liberty Memorial H. S.): Pearl I. Carpenter, Ben Franklin Club of Liberty Memorial H. S.

Lawrence (Univ. of Kan.): Myrl R. Adams, Glenn C. Bond, Ernest Boyce, Florence Briscoe, Ruth Cady, Cora M. Downs, Harriet A. Geer, Elmer A. Hof, H. Wallace Lane, Amos Leech, R. C. Moore (1934), Edna Old, Norman A. Preble, Noble P. Sherwood, Ruth Stockard, Paul M. Strickler, Daphne B. Swartz, Robert W. Warner.

Lawrence (State Bd. of Health): Paul Haney.

Lincoln, Neb.: Dolores Quinn.

Lindsborg (Bethany Col.): H. G. Underwood.

Manhattan (K. S. C.): Isabelle Gillum, E. G. Kelly, H. W. Marlow, Ivan Pratt, Arlene Smith.

Manhattan (U. S. D. A.): Richard T. Cotton, H. D. Young.

Portis: High School Jr. Acad., sponsor, S. J. Neher.

Richmond: Wilbur Doudna.

Sterling (Sterling Col.): Coyle Wellman.

Topeka: David P. Beaudry, Sr.

Topeka (H. S.): Margarett Groeber, Abigail McElray, Grace G. Wolcott.

Topeka (Washburn Col.): Jane L. Ayers, Sarah L. Doubt, Robert H. Kingman, Wm. J. Morgan.

Walton: John W. Bell.

Wichita: W. A. Talbott, Jr.

Wichita (Univ. of Wichita): L. A. Crum, Harold Duerksen, Chas. Williams.

Wichita (Friends University): Dorrice Snyder.

Winfield (Southwestern Col.): C. Rogers.

Summary of Membership, May 25, 1935

Old members paid up	219
New members	64
Total annual membership	283
Life and honorary members	61
Total	344

New Developments. Through the efforts of the committee on state aid, the Academy was continued on the budget which was passed by the Legislature appropriating $300 for each of the next two years for the distribution of the transactions.

The following reports of the treasurer and of the endowment committee were read and accepted:

REPORT OF TREASURER

April 26, 1934, to March 29, 1935

Receipts

Balance on hand, April 26, 1934	$35.96
Dues from members	808.00
Received from A. A. A. S.	61.00
Sale of reprints to members	98.00
Sale of back volumes of Transactions	18.65
Kansas University, exchange rights, Vol. 36	200.00
Kansas University, exchange rights, Vol. 37	200.00
Fort Hays Kansas State College, exchange rights, Vol. 37	100.00
Principal and interest, cert. deposit, F. N. B., Hays	101.50
Interest on endowment fund	37.50
Wichita University contribution to speaker's fund	24.00
Refund on treasurer's ledger, H. A. Z.	1.35
Overpayment by secretary	2.00
Legislature appropriation, 1934	300.00
Total	$1,487.96

Disbursements

Kimball Printing Co.	$186.02
Doctor Baumgartner: Topeka and drawings (Surla)	14.02
S. D. Flora: Fare to Wichita	8.22
Dr. R. C. Moore: Fare to Wichita	15.02
Secretary's fare, A. A. A. S. meeting at Boston	65.00
Goldsmith Book and Sta.: Ledger	1.35
Certificate of deposit, F. N. B., Hays	100.00
Treasurer's ledger in error, H. A. Z.	1.35
Postal Savings certificate, G-305264	100.02
Editor: Topeka and refund	12.45
Secretary's office help	21.58
Topeka Trucking Terminal: Hauling	3.62
U. S. Treasury savings bond, L-108609, Series A	37.50
Elliott Addressing Machine: Stencils	7.68
Five $100 Postal Savings certificates, G-471968-72	500.00
Capper Engraving: Cuts	215.78
Crane & Co.: Envelopes	21.25
Postmaster, Manhattan: Stamps	62.97
Balance on checking account	114.13
Total	$1,487.96

Supplementary Statement on Financial Condition of Academy

Bank balance		$133.61
Six $100 U. S. Postal Savings certificates		600.00
Due from K. S. C. of Agr. and App. Sci., Rights Vol. 37		200.00
Total		$933.61
Uncanceled checks	$19.48	
Payable to endowment fund	2.51	
Total		21.99
Net balance		$911.62

Respectfully submitted,

Harvey A. Zinszer, *Treasurer.*

REPORT OF ENDOWMENT COMMITTEE

Receipts

Balance in general fund	$2.51
Earnings during 1934	37.50
Total	$40.01

Disbursements

One $50 U. S. Treasury savings bond, L-108609, Series A	$37.50
In general fund	2.51
Total	$40.01

INVESTMENTS

4 shares (AC99-AC102) Morris Plan, Wichita, at 6 percent	$400.00
8 shares (No. 7859) Greene Co. B. & L., Springfield	300.00
5 shares Class C, Western S. & L., Kansas City	300.00
1 (11859-K) U. S. Treasury bond, 1951-1955, at 3 percent	100.00
1 (670-L) U. S. Treasury bond, 1951-1955, at 3 percent	50.00
1 (L-108609, Series A) U. S. Treasury savings bond, 1945	37.50
In general fund	2.51
Total	$1,190.01

This year Greene County Building and Loan defaulted both the fall and spring interest payments, amounting to $9 each. The Bureau of Building and Loan Supervision of Missouri predicts that shareholders in this company will eventually come out 100 cents to the dollar. The Western Savings are still operating on a 3 percent interest rate.

ZINSZER, GRIMES, JOHNSON and BREWSTER.

March 29, 1934.

The auditing committee reported that the reports of the treasurer and the endowment committee had been checked and found correct.

The outgoing chairman of sections announced the election of the following for 1935-'36:

Botany: L. E. Melchers, Kansas State College.

Chemistry: C. H. Whitnah, Kansas State College.

Entomology: Kathleen Doering, president; D. A. Wilbur, vice-president; R. L. Parker, secretary-treasurer.

Physics: H. A. Zinszer, Fort Hays Kansas State College.

Psychology: B. A. Nash, University of Kansas, president; Beulah Morrison, University of Kansas, secretary.

Junior Academy: Hazel E. Branch, University of Wichita.

Zoölogy: J. E. Ackert, Kansas State College.

The attendance at the meetings was reported as follows: Friday, general, 150; Botany, 55; Zoölogy, 65; Chemistry, 50; Physics, 42; Psychology, 30; Junior Academy, 240 young folks and 25 adults; Saturday, general, 70; Entomology, 75; the lecture by Dr. Ralph H. Major, Thursday evening, 350; the lecture by Dr. A. E. Douglas on Friday evening, 800; banquet, 200.

The chairman of the publications committee read the following report, which was accepted:

REPORT OF THE PUBLICATION COMMITTEE

The manuscripts complete for volume 37 were turned over to Professor Baumgartner late in May. The plates and cuts were made during the summer, but owing to various delays the volume was not actually set in type until late in the year and distributed in February of 1935.

The chairman of the state aid committee read the following report, which was accepted:

REPORT OF THE COMMITTEE ON STATE AID

The committee secured the publication of the "Transactions" by the state printer, who reported the costs in his office of the 1,000 copies and 200 reprints to be $1,630.52, and the cost of regular commercial production according to the NRA codes to be $1,912.55.

The committee again secured the $600 from the legislature.

The committee suggests that the Academy, through its officers, send a letter to the state printer, Mr. W. C. Austin, expressing to him its great appreciation for the production of the excellent volume.

W. M. KRAUS,
F. U. G. AGRELIUS,
W. J. BAUMGARTNER, *Chairman.*

The following report by the chairman of the Junior Academy committee was read and accepted:

JUNIOR ACADEMY OF SCIENCE—FOURTH ANNUAL MEETING

On Friday afternoon, March 29, 1935, at 1:30, the following program was given by six affiliated clubs and one interested and visiting group. There were two hundred and forty high-school students and twenty-five adults in attendance.

PROGRAM

President, Maurice Ransom, Wichita High School East, and Secretary, Dan La Schelle, Junction City High School, Presiding.

Liberty Memorial High School, Lawrence, Kan.:
- Ben Franklin Club: Sponsors, C. B. Cunningham and R. E. Wood.
  - A. Physics Group:
    - Tesla Coil and 250,000 Volts.....Alex Mitchell and Marshall Gorrill
  - B. Chemistry Group:
    - Dry Ice................Hugh Magruder and Mariana Cunningham

Lawrence Junior High School, Lawrence, Kan.:
- Lawrence Nature Study Club: Sponsor, Miss Edith Beach.
  - Paramecia Studies ....Bill Collins
  - A Collection of Cacti.................................Maurice Jackson
  - Chemistry as a Hobby.....................................Edwin Price
  - A Tin Can Slide Machine..............................Harold Leffman

Wichita High School East, Wichita, Kan.:
- Chemistry Club: Sponsor, J. A. Brownlee.
  - A Gas Generating Apparatus..........................Elinor Brownlee
  - A Formula for Making Firecrackers.......................Chas. Dickey
  - A Playlet ....Announcer, Bill Corbett

Shawnee Mission Rural High School, Merriam, Kan.:
- The Retorts: Sponsor, James A. Hawkins.
  - Exhibition of Mounted Butterflies.......................Virginia Griffin
  - An Iodine Clock...Larry Calkins

Junction City High School, Junction City, Kan.:
- Science Club: Sponsor, H. R. Callahan.
  - Induction Motors ....Edwin Burnett

Portis High School, Portis, Kan.:
- The What and Why Club: Sponsor, S. J. Neher.
  - A Plant Collection......................................Merlin Neher
  - An Intermittent Gyser.....................................Paul Dutton

Topeka High School, Topeka, Kan.:
- An Interested Group: Sponsor, Miss Margaret Graeber.
  - An Insect Collection....................Bud Spencer and James McClure
  - Reptiles ....Grace Kline

Induction of new clubs: The Retort,* What and Why, Ben Franklin.

Election of officers: President, Edwin Price; secretary, Virginia Griffin.

Awards: The Retorts, of Shawnee Mission, first; The What and Why of Portis, honorable mention.

Entertainment: Under the sponsorship of Miss Edith Beach, the out-of-town students were entertained Friday night and Saturday by the members of the Ben Franklin and the Lawrence Nature Study Clubs. This courtesy was greatly appreciated by the visiting students and the chairman of the committee. Thank you.

Judges: Miss Nellie Wismer, of Lawrence, and Miss Frances Wright, of Wichita.

HAZEL E. BRANCH, *Chairman.*

* Third year but first attendance.

The committee on natural areas and ecology made the following report, which was adopted:

REPORT OF COMMITTEE ON NATURAL AREAS AND ECOLOGY

Committee recommends that the Kansas Academy of Science contribute five dollars ($5) to the work of Committee on the Preservation of Natural Conditions for the United States of the Ecological Society of America.

WALTER H. SCHOEWE, *Chairman.*

The resolutions committee presented the following resolutions, which were adopted:

RESOLUTIONS

Be it resolved:

1. That the Kansas Academy of Science extends its thanks and appreciation to the University of Kansas for the excellent facilities furnished the Academy for conducting the various sessions.

2. That we extend, through the secretary, our appreciation for the interesting and instructive lectures by Dr. Ralph H. Major and Dr. A. E. Douglass.

3. That we extend well-deserved thanks to the officers and various committees responsible for the splendid preparations for our annual meeting.

4. That we express our sincere appreciation to the members of the Committee on Publication for the fine results of their work as shown in our recent volume of Transactions. This volume is aiding noticeably in securing additions to our membership.

5. That we appreciate the generosity of the state for its share in the printing of our Transactions and wish especially to thank Doctor Baumgartner for his efficient work before the last two legislatures.

6. That we sincerely regret the recent passing of our faithful and efficient secretary, Dr. George E. Johnson, and that we express to his wife our deepest sympathy in her great loss.

7. That the Academy in general assembly devote a minute of silence in its program in honor of Dr. George E. Johnson.

8. That we thank the local Chapter of Sigma Xi for sponsoring the lecture by Dr. Ralph H. Major on Glimpses of Germany and for providing the local committee with all necessary funds.

9. That we thank the University Convocation Committee for sponsoring the lecture on Tree Rings and Their Relation to Chronology and Climate presented by Dr. A. E. Douglass.

Committee: F. U. G. AGRELIUS, *Chairman,*
WILLIS W. FLOYD.

Following the adoption of the resolutions, the committee stood in silence from 9:44 to 9:45, at the close of which the secretary read Mrs. Johnson's expression of appreciation for the Academy remembrance at the final services for Secretary Johnson.

The committee on coördination of science groups had no report to make, and since the function of this committee is handled by the executive council, this committee was discontinued.

The necrology committee (Rankin, Melchers, Wilson) presented the following obituaries:

GEORGE EDWARD JOHNSON, 1889-1935

Dr. George Edward Johnson, Professor of Zoölogy, Kansas State College, and for a number of years secretary of the Kansas Academy of Science, died March 18, 1935, after an illness of several months. Doctor Johnson was well

known for his research in zoölogy, being mammalogist for the Kansas Agricultural Experiment Station, where he directed the extermination work of rabbits, prairie dogs, gophers, moles, and other objectionable animal pests. He was perhaps the most outstanding figure of the Kansas Academy of Science, of which he served so faithfully as secretary and as a member of the executive committee since 1928. He was responsible for reorganizing the Academy into sections. His efforts were largely responsible for lifting the Kansas Academy onto the high plane upon which it now stands. Those who knew him best realize that next to his research work his chief interest was in this organization.

Doctor Johnson received his bachelor of science degree in 1913 from Dakota Wesleyan University, Mitchell, S. Dak. In 1916 he received his master of science degree at the University of Chicago, and in 1923 was awarded the degree of doctor of philosophy by Harvard University. In 1924 he became a member of the faculty of Kansas State College. He was the author of numerous scientific articles, most of which dealt with the physiology of hibernation and endocrinology. He held memberships in the American Society of Mammalogists, the American Society of Zoölogists, Gamma Alpha, Gamma Epsilon Delta, and Sigma Xi, honorary fraternities.

ELAM BARTHOLOMEW, 1852-1934

Elam Bartholomew was born at Strasburg, Pa., on June 9, 1852. He was the fourth son of a family of eight sons and one daughter. His paternal ancestor, Henry Bartholomew, six generations back, came from Holland. When Elam was a small boy his parents moved to Granville, Ohio. In 1865 the family removed to a farm near Farmington, Ill., where he grew to manhood. By attending the district school in the winter months and by assiduous home study, he fitted himself for teaching. He taught a five-months term in a district school, then decided to migrate to the west. He arrived in Hays, Kan., in 1874, and soon afterward drove to a point northwest of Stockton, where he homesteaded on a quarter section in the beautiful Bow Creek valley. On this farm he maintained a residence for fifty-five years. In 1929 he became curator of the mycological herbarium at the Fort Hays Kansas State College. He was still occupying this position at the time of his death, November 18, 1934.

Doctor Bartholomew, though he had no college education, early in life developed a keen interest in natural science, especially in its biological phases. His special interests were in plant diseases, and he came to be recognized internationally as a discoverer, collector, and distributor of thousands of forms of fungous plants. He collected over 290,000 specimens, traveling more than 125,000 miles to do so.

In 1898 the Kansas State College, recognizing his ability and scholarship, conferred on Mr. Bartholomew the degree of Master of Science. His thesis subject was, "The Plant Rusts of Kansas." In 1927 he was again honored by the same institution with the degree of Doctor of Science. His thesis for this occasion, "The Fungous Flora of Kansas," was later published as a special College Bulletin.

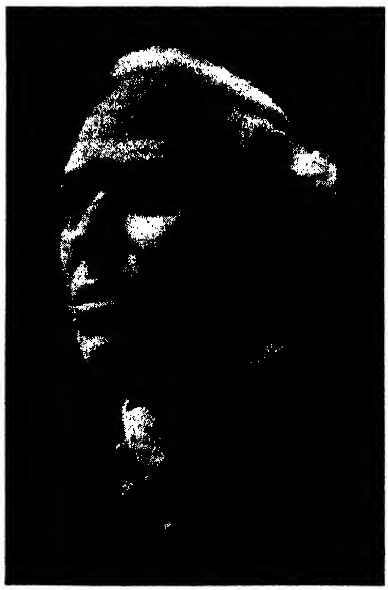
For sixteen years Doctor Bartholomew was editor and publisher of "Fungi Columbiana." He was also editor and publisher of "North American Uredinales." He was a member of the American Association for the Advancement of Science, the American Phytopathological Society and the National Historical Society.

Any sketch of Doctor Bartholomew's life would be incomplete without some mention of the companion who shared his life and labors, Mrs. Rachel Montgomery Bartholomew, who survives him after fifty-eight years of close companionship. His tremendous achievement could never have been accomplished without her patient and efficient assistance.

ELAM BARTHOLOMEW

CHARLES MORGAN STERLING

ANNA E. HARMS



JAMES WILLARD MAYBERRY

CHARLES MORGAN STERLING, 1864-1934

Charles Morgan Sterling, member of the Kansas Academy of Science since 1904 and life member since 1923, died at his home in Lawrence, Kan., September 23, 1934. He was born in Preston county, West Virginia, March 22, 1864, son of Andrew Jackson Sterling and Elizabeth Scott Sterling. The family moved to Whiteside county, Illinois, in 1865 and settled in Dickinson county, Kansas, in 1871.

He was graduated from the University of Kansas in 1897 with the degree of Bachelor of Arts. Following his graduation he was elected to the faculty of the University of Kansas and continued in service until his death. He was associated with the School of Pharmacy, where, since 1926, he held the position of associate professor of Pharmacognosy.

His life work was devoted to the subjects of botany and vegetable histology, with special reference to drugs. As a microanalyst he was an outstanding authority, and contributed extensively from his field of micropharmacognosy to the revisions of the United States Pharmacopoeia and the National Formulary. He served for many years, in an advisory position, the Kansas State Board of Health and the Kansas State Board of Agriculture in matters pertaining to the identity of drug tissues in connection with the enforcement of the drug laws of the state of Kansas.

He was a member of the honorary societies of Phi Beta Kappa and Sigma Xi.

Professor Sterling was married to Harriette Fellows, July 5, 1900, and is survived by his wife and three of his four children, Philip, Francis, and Marcella.

JAMES WILLARD MAYBERRY, 1870-1934

James Willard Mayberry was born in Hilltown, Pa., near Pittsburgh, on September 23, 1870. He moved to Kansas in 1877 with his parents, J. K. and Sarah Mayberry, settling on a farm near Chase in Rice county, where he grew to manhood. He attended McPherson College and later went to the old Emporia Normal, where he secured his life certificate in 1893.

After teaching in a country school at Galva, he became superintendent of the Larned schools in 1895 and remained there until 1898, when he went to the University of Kansas to take his Bachelor's Degree. He later went to Perry, Okla., in the Indian territory, to become superintendent of schools, remaining there less than a year, resigning to become head of the Department of Chemistry in the Central State Normal School at Edmund, Okla. He took his Master's Degree at the University of Kansas. In 1907 he took a job in Epworth University, similar to that at Edmund in the Normal School, but he also served as Dean, remaining with that institution until 1913, when he returned to Kansas to become head of the Department of Chemistry of the Emporia State Teachers College. He continued in that capacity until his death, which occurred in the Hertzler hospital at Halstead on September 3, 1934, following a minor operation.

He was the author of a dozen textbooks on the subject of physiology, health and hygiene. He published numerous magazine articles, and spoke frequently, giving professional and educational lectures and commencement addresses as well as scientific demonstrations. He also gave many chalk talks and made a hobby of drawing and painting, having illustrated his own books.

He traveled extensively in Kansas and Oklahoma and was widely known in both states and had conducted professional institutes in dozens of counties in both states. He handled the student loan fund of the Emporia Teachers College for a period of twenty-one years and personally supervised the loans to hundreds of students. Throughout his career he was active in civic and commercial organizations of his home town and in the Methodist Church, of which he was a member from early boyhood.

He is survived by his widow, Mrs. J. W. Mayberry, of Emporia, his son, Willard Mayberry, of Elkhart, two daughters, Mrs. Mignon Swenson, of Elkhart, and Mrs. Harold Hunt, of Wellington.

Anna E. Harms, 1898-1935

Anna E. Harms was born September 19, 1898, near Lehigh, Kan. Her childhood was spent on the farm with her parents. From 1920 to 1923 she taught in the public schools in her home community. She attended the University of Kansas, the University of Colorado, and Tabor College. She was granted the A.B. degree from this last-named institution in 1927. In 1930 she received the M.A. degree from the University of Minnesota.

Miss Harms taught for some time in her alma mater, Tabor College, then later in Central College, McPherson, Kan. She was a highly respected member of the faculty of Central College at the time of her death, January 9, 1935.

Those who knew Miss Harms speak in the highest terms of her fine character and her sincere devotion to her duties as a teacher.

The following amendment to the constitution, which had been presented at the business meeting the day before, was again read, discussed, and adopted:

"Section 8. This Academy shall have an editorial board consisting of an editor, a managing editor, and four associate editors. These members shall be elected in the same manner as other officers, but for a period of three years. Two members of the board shall be elected every year.

"The editor with the aid of the associate editors shall have general supervision of all editorial work submitted for publication in the Transactions and shall be responsible for the selecting, editing, revision and rejection of papers submitted for publication. The managing editor shall be responsible for the making of the plates and the printing and general distribution of the Transactions."

(Note: It is understood that in 1935 the editor and one associate shall be elected for three years, the managing editor and one associate for two years, and two associates for one year.)

With the passage of this amendment, the publication committee, as a committee, ceased to function, and the work was taken over by an editorial board as elected officers of the Academy.

The Academy voted to accept the cordial invitation to meet at Emporia in the spring of 1936.

The nominating committee presented the following nominations for officers: President, W. J. Baumgartner; first vice-president, L. Oncley; second vice-president, H. H. Hall; secretary, Roger C. Smith; treasurer, H. A. Zinszer; additional members of the executive council, W. H. Matthews, W. H. Schoewe, E. A. Martin; editor, F. C. Gates; managing editor, W. J. Baumgartner (2 years); associate editors, Robert Taft (3 years); G. A. Kelly (2 years); E. O. Deer (1 year); W. W. Floyd (1 year).

Upon motion a unanimous ballot was cast for these persons and they were declared elected. President-elect Baumgartner was called to the chair and the reading of papers resumed.

The meeting adjourned at 11:10 a.m.

At a meeting of the new executive council, immediately following adjournment and by correspondence later, President-elect Baumgartner appointed the following committees:

Endowment and Investments: Zinszer, Grimes, Smith, and Brewster.

Natural Areas and Ecology: Schoewe, Burt, H. H. Hall, W. H. Horr, Matthews, and L. D. Wooster.

Junior Academy: Hazel E. Branch.

State Aid: Baumgartner, Matthews, Agrelius.

Membership: Smith, Agrelius, Rankin, Dellinger, Kingman, R. H. Wheeler, and Jewett.

Necrology: Rankin, Melchers, Wilson.

Resolutions and Auditing: The committees on resolutions and auditing and nomination remain to be appointed at or previous to the next meeting.

On vote of the council necessary additional sections which do not start until after the business meeting Friday morning may be organized by various groups in addition to the section meetings Friday afternoon.

FRANK C. GATES, *Secretary pro tem.*

PAPERS AND ABSTRACTS

SIXTY-SEVENTH ANNUAL MEETING, LAWRENCE, 1935

Presidential Address:

Scientific Development and Investigation in Southeast Kansas

WM. H. MATTHEWS, Kansas State Teachers College, Pittsburg, Kan.

The greatest development in the southeast section of Kansas in which science has had a part is in the mining of coal. This development has been in one type of mining, namely, "strip mining"; and it has been to such an extent that very few deep mines in which coal was mined by the room-and-pillar method are in operation at the present time. Most of the mining companies that were engaged in deep mining have withdrawn from the field.

In strip mining all the overburden is removed from the coal, and the greatest development has been in the machinery and methods used in removing this overburden. In the beginning of this type of mining men used picks and shovels for uncovering the coal, and the mining activities were confined to places where the overburden was but a few feet in thickness, usually along streams where erosion had removed much of the top dirt. As the demand for coal grew, better methods were devised for mining. In the early eighties, such teams and slips were employed as were in use in making cuts and fills in railroad building. With this type of equipment it was feasible to remove 12 feet of overburden in order to reach the 3-foot seam of coal, thus removing 6.8 tons of earth for each ton of coal. Mining men of that period say that a man and team using the necessary plows and scrapers could remove about 30 cubic yards of overburden in a ten-hour shift.

In the year 1898 the Kansas and Texas Coal Company installed a steam shovel at a point about three miles southwest of Pittsburg, but for some reason the experiment was not considered a success and the equipment was removed from the field. About twenty years later steam-shovel mining was started in earnest. These shovels were equipped at first with a one-yard dipper, but it was not long until six- and seven-yard dippers were being used.

The next development in this type of mining was the electric shovel, and the first electric shovel installed in this district was in the year 1918 by the Pittsburg Midway Coal Mining Company. This first electric shovel was equipped with alternating-current motors which were serviced through a 4,000-volt line. This machine moved about 2,200 cubic yards of overburden in a 9-hour shift.

Voltage fluctuations caused by this machine were very severe and necessitated the installation of an automatic controlled 450-kv.a. synchronous motor for the correction of the very poor power factor of the a.c. motor equipment.

In 1927 this same coal company purchased the first large synchronous motor-generator set operated shovel to be installed in this field. This 800 kv.a. 16-yard shovel is operated with direct current and is representative of the type of new shovels being used by the various companies in the field. A modern electric shovel removes approximately 400,000 cubic yards of earth per month, thus uncovering about 8.7 acres of coal per month and uses .3 kilowatt hours of electrical energy per cubic yard of earth removed.

The coal mined in these strip mines is sorted as to size by screening, and, in a great many plants, all the coal up to three inches in size is washed. The washing of coal is one of the new developments in this field. One company paints its washed coal with a water soluble dye of a greenish gold color, so that the customer will know when he is buying washed coal. Coal washers have been installed at several of the plants. In these the coal is floated, while the pyrite and other heavy waste materials sink to the bottom of the washer.

The power plant at Service, Kan., operated by the Kansas Gas and Electric Company, and the Empire District Company's power plant at Riverton, Kan., furnish power for these mines. The Riverton plant furnishes 25-cycle power while the Service plant furnishes 60-cycle power. These two plants are connected together through a 25,000 kv. a. frequency changer.

The Riverton plant is the most interesting of the two from the viewpoint of machinery development. The first electrical unit installed at this plant was a hydro-electric unit, built in 1900, at the point where Shoal creek joins Spring river in the southeast corner of the state. A large lake resulted from the construction of a dam for this plant, and in turn this made an ideal location for a steam electrical plant, as the other desirable features for a power plant were existent, namely, cheap fuel and a market for power.

The first unit installed in the steam plant was a large reciprocating engine connected to a 2,000 kv. a. generator. This unit had been in use at the World's Fair at St. Louis in 1903-'04 to furnish power for lights in the Pike. The next unit installed was a low-pressure turbo-generator, the turbine of which was furnished with steam from the exhaust of the large reciprocating engine. This unit also generates 2,000 kv. a. In a short time a 5,000 kv. a. turbo-generator was added. All of these machines were retired several years ago; not because they were worn out but because of the efficiency of new machinery.

New units have been added to this plant at intervals and now the plant is rated at 70,000 kv. a. The original hydro-electric plant of 2-1,500 kv. a. machines is still in operation, but is only operated when there is a surplus of water in the lake.

I conducted classes for the employees at the Riverton plant, 23 miles south of Pittsburg, Kan., for ten consecutive years, during which time the number of employees was reduced from about 160 to about 70 men, although the rated output of the plant was doubled.

The Service plant, owned by the Kansas Gas and Electric Company, is located 26 miles west of Pittsburg. This plant is a modern steam plant, fired with coal, and has a maximum output of 40,000 kv. a.

The developments described in mining and in the generation of electric power have left many problems in their wake. One of the problems most evident is the thousands of acres of waste land resulting from mining, the land having been turned completely up side down to a depth of from twelve to forty feet and piled in great mounds. These mounds were named by the people in the section as "dumps" or "strip-pit dumps." Some of this land has been leveled off and planted to walnut and hickory nut trees. This work has been done by the boys of three CCC units that are located in the district.

The Crawford County State Park, located but a few miles from Pittsburg,

is on 480 acres of land that has been mined by the strip-mining method. Of this 480 acres of land, 60 acres are covered with water. These ponds have been stocked with fish. Roads have been built and a few trees have been planted, but most of the trees growing on the mound are of volunteer origin and seem to have a very rapid growth in the loose shaly earth. The amount of water described at the park is typical of the water on all this mined land. I do not think that a careful survey has been made to determine this amount of water, or how much of it is suitable for stocking with fish; or what trees, shrubs, or plants, have the best growth on the mounds. Fruit trees, berries, grapes, etc., have been planted over small acreages and seem to grow very well.

Perhaps the most serious problem of all is the number of workers that are without employment because of the radical changes in the methods of mining coal. An electrical shovel mine will produce more coal with less than fifty men than could be produced by the old methods of deep mining by several hundred men, and the operations have very little in common. A man may be experienced to a high degree as a worker in a deep mine, such as an entry driver, a track layer, an air man, a gas man, a cager of coal, or a practical miner skilled in the cutting and shooting of coal; yet he would have very little from his experience to carry over to the newer methods of mining.

I have tried to give you a picture of what the effect of the development of machinery has been to the workers in one particular section of our state. The problem is not confined to one community, however, but extends to the entire union of states. Now I do not feel that scientists should begin to accept responsibility for the social or economic consequences of their discoveries, but I do know that they will lend helping hands when the opportunity presents itself. The remainder of my paper, therefore, will be relative to that subject.

The late Dr. J. A. Yates, a life member and a past president of the Kansas Academy of Science, came to the Kansas State Teachers College of Pittsburg in 1907. Deep coal mining was almost at its peak and deadly mine explosions were common. Doctor Yates was not a mining man, but he did know the chemistry of combustion and explosive gases. He organized classes of miners and made a study of the causes and prevention of these explosions. After conducting these classes for several years he trained practical miners as teachers and sent them out to teach mining in the smaller mining towns. The result of their teaching is that every state or deputy mine inspector, gas man, hoisting engineer or any employee in a responsible position must hold a state license showing that he has passed the state board and is competent.

The success in the training of adults in better methods in the mining of coal led to the organization of classes in other vocations, such as electrical subjects, gas engines, etc. Finally, the federal law, known as the Smith-Hughes law, relative to vocational education, was enacted, and this made possible the financing of classes in vocational education. Time would not permit the reviewing of the history of all the fine work that has been done because of the state and federal aid in adult education; so I will sketch only the work done in the last few years in the southeast section of Kansas.

I worked with Doctor Yates in a great deal of the development that I have described and, for a teacher of physics with some background in the fields of mining and electricity, it was a delightful experience. Two years ago I was made director of this work. Now I do not mean to imply that I have left the

field for which I was trained; I direct this work merely as a kind of an *"extra-curricular activity."*

In coöperation with Mr. C. M. Miller, the state vocational director for Kansas, we have organized classes in adult vocational education whenever the need presented itself. The aims of the program are to give people training in their particular field, to aid them to change from one field to another when "machined" out of a job, to help them get more joy out of their work, and to give training that may lead to promotion for those more deserving.

Do you know that the average man changes his vocation at least three times during the span of a lifetime? He may make the change voluntarily with the thought of bettering his condition, but more often he has been forced to make the change. Maybe he has been "machined" out of a job; perhaps the concern by whom he was employed has quit business. Reason after reason could be given why men change their vocation.

Vocations themselves are also changing. For instance, a few years ago a good boilermaker was a good riveter, but now very few rivets are being used. Electric welds have taken their place, and skill in welding is one of the new things this tradesman must acquire in order that he may work at his trade.

The automobile mechanic of today, if he is efficient, must know how to use an acetylene torch and how to operate a machine lathe. He should know something about radios and a number of operations that were not in existence during the time of his apprenticeship. Where will he acquire skill in these new additions to his trade? There are few answers to this question. One might be by the trial-and-error method at the expense of the customer, another in some class in vocational education.

New vocations are opening up from time to time and the person that sees a danger of his losing employment because of new methods, more efficient machinery, etc., must turn to some agency where he can receive information and training that he may change to the new type of work with the minimum loss of time. Some of the new vocations of the past few years, such as electrical appliances, radio, electric welding, refrigeration, air conditioning, etc., are fields in which the vocational educators see possibilities.

I will not describe all the work that has been offered under this adult-educational program during the past two years, but I will discuss some of the most interesting projects. A class in elementary ceramics was conducted for forty-eight employees of a large tile manufacturing company, by a member of the staff of the college physical science department. Experts in various lines related to ceramics were invited to attend the class and lead in discussion. That is, matters related to clays were discussed by a geologist, combustion and temperature measurements by one trained in that field, machinery by an engineer, etc. The management of the plant at which these men are employed believes that many changes should be made in the operational processes of the plant, and that worthwhile ideas will come from the workers when they know the problems confronting the management. These problems are discussed in the class meetings.

A class was organized last fall for those interested in studying the fundamentals of refrigeration and air conditioning; it, too, was taught by a member of the physical science staff.

A survey, made by responsible parties about a year ago, indicated that the depression was showing its effect on the health of children of school age in certain communities. The findings of this survey were the direct cause of a graduate nurse being trained to teach classes in home nursing. Classes in home nursing were organized, and several hundred mothers have completed this short course since July first of last year. About seventy-five are in attendance in the same nursing classes at the present time.

Courses in radio and automobile electricity are taught by men that work at these respective vocations.

For fourteen years classes have been conducted for the employees of the Empire District Power Company. These classes meet in a room at the power plant. The course has been a varied one. Electricity was the first subject taught and it has been repeated several times since the beginning. Power-plant problems, combustion, steam generation, power-plant chemistry, mathematics, etc., are some of the subjects given.

The enrollment in classes in vocational education increases from year to year; classes grow larger; attendance gets better. About fourteen hundred adult men and women were enrolled in these classes during the last year. Some of these people have been in attendance for a number of years.

I have tried, in a hurried way, to describe some of the industrial and scientific developments in southeastern Kansas, certain vital problems resulting from these developments, and the place that science education holds in this whole scheme of things.

LANTERN SLIDES EXHIBITED

1-2. Early steam shovels.

3-4. Shows the coal seam, its thickness, etc.

5. The dipper of the first electric shovel.

6. One of the Commercial Fuel Company's mines.

7. The 16-yard dipper of the Pittsburg and Midway Mining Company's shovel. This dipper has been replaced by a 20-cubic-yard dipper, and strange to say this 20-cubic-yard dipper weighs 200 pounds less than the original 16-yard dipper, which weighs 5,800 pounds. The reason for this difference in weight is that the new dipper is constructed largely of aluminum.

8-9. Boom and dipper of one of the Klaner Coal Company's shovels.

10. The size of the 16-yard dipper as compared to the size of an automobile.

11. A large shovel just starting to dig in.

12. A view of the same shovel.

13-14-15. In the pit.

16. A large swing gear which operates the boom. 300 to 500 pounds of lubricant is used per day on this gear.

17. One type of coal loader.

18-19-20. Views of shovels.

21. Another method of loading.

22-23. Dinkey engines are sometimes used to pull the loaded cars of coal to the tipple.

24-25-26. Modern coal tipple, where the coal is cleaned and sized.

27. Sizing of coal.

28. Tipple under construction.

29-34 (incl). Crawford County State Park.
36. Strip pits near Scammon where the CCC boys are working.
35-36. Leveling the dumps that trees may be planted.
39-40. The Kansas Quail Farm.

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Some Myths of the Hoh and Quillayute Indians

ALBERT B. REAGAN, Brigham Young University, Provo, Utah

1. INTRODUCTION

Thirty-six miles down the Pacific coast southeast of Cape Flattery, at the entrance of the Strait of Juan de Fuca, is the Indian village of Quillayute (sometimes spelled Quileute). And farther to the southeastward down the coast, opposite Destruction Island and its rocks of destruction, is the village of Hoh, at the mouth of the river of the same name. The people of these two villages are relatives, being both of the Chemakum linguistic stock, and probably were once one people, even after they came to the Pacific side of the Olympic peninsula. Moreover, most of the Hohs now live at Quillayute (Quileute, now known as LaPush) instead of at Hoh.

As a government official, the writer had charge of these two Indian villages from July 1, 1905, to October 15, 1909, and while thus employed he made a study of their myths. Some of these are given below.

The writer wishes to add that in giving the myths he has tried to keep to the Indian idiom of expression, in cases sacrificing or "stretching" the English to carry out the same. He also wishes to add that his informants, often two or more of them colaborating on the same myth, were Hal George, Johnson Black, Carl Black, Luke Hobucket, Harold Johnson, Klakishkee, Bucket Mason, Elon Mason, Arthur Howeattle, M. B. Penn, Mrs. Jimmie Howe, Frank Bennett, Klekabuck, Kikabuthlup, Dixon Payne, Weberhard Jones, Eli Ward, Jack Ward, Beatrice Pullen, Mark Williams, and Sallie Black.

2. A HOH MYTH

Once in the long ago our chief medicine doctor went in spirit, sent his "tomanawis" to ascertain if it was the proper time to go elk hunting, if a hunting expedition would be successful.

For four days he remained in a trance state, while the people danced around him and prayed to their deities. Then, his spirit returning, he sat upright and blew his breath in blessing on those present. Then, as they breathlessly listened, he related his experience, saying:

"I went in spirit up the river and pitched my tent at Forks prairie, where I saw a man hunting elk with a dog. There were lots of elk there. These the dog saw and chased from prairie to prairie; but the hunter could not get near them, as the dog scared them.

"Night came, another, and still another, and no elk were killed. Then, as the hunter had eaten all the provision he had brought along with him, he returned to his home down the river.

"When he arrived at Quillayute his people made fun of him. A woman gave him some dried meat to eat. At that juncture his father came by and threw the meat into the fire, saying: 'Why do you not kill your own meat? You hunt; why do you beg? Is your tomanawis no good?'

"The next day the hunter went back to the prairie, taking some whale meat with him, but no dog.

"For three days more he traveled toward the up-country. He then drew his canoe ashore and constructed an improvised wigwam. He began to feel sick, 'tomanawis' sick. He began to put the pieces of whale meat on the fire, one by one; as the smell of whale meat is pleasing to the gods.

"As he dropped the last piece of the meat on the fire, all the birds of the whole earth and all the beasts of the land gathered around the little house and roared and bellowed and sang.

"At the same time a two headed monster, a beast with head before and behind, came from the great depths and stood before him. He sprang and grabbed it, and he immediately became unconscious. The blood oozed out of his mouth, and he rolled over and over on the ground and strangled furiously. The beast then entered him and became his 'tomanawis' power in hunting elk.

"As soon as he became conscious again, he started to go home, and as he was thus leaving the 'tepee,' he saw an elk looking oppositely from him. He hallooed at it. It turned and, on seeing him, instantly fell dead, his 'tomanawis' killing it. And he soon had his canoe filled with elk meat.

"I looked again and a huge monster appeared before me. From a dark hole in a mountain near it a stream of blood was running down into the valley. To the left as I looked, a slug-snail-skin belt of gigantic size also appeared; and to the right among the trees stood an elk waiting to be killed. On top of the mountain was also a man of the gods, wearing a 'tomanawis' head-band; and—when the latter saw that I was looking at him, he beckoned me to come.

" 'Yes, the elk are yours,' he continued after a short pause. 'Let us go to the slaughter.'

"The next morning at a very early hour, our hunters all danced down to the river's brink, as they sang and chanted to the deities. Then, with provisions to last several days, including a goodly supply of whale meat, they set out up the river in their quest.

"They went up the Bogachiel river far into the mountain country, where they found lots of elk signs. There they pitched their tents and set out at once on their hunting expedition in the timber line, grassy areas and among the mountain slopes.

"Each day they brought in loads of elk meat; for they never drew a bow but they killed an elk; the elk would come out of the woods and stand to be shot. They killed elk till they wished no more meat. The meat they then dried. The sinew they saved for making ropes, splicing harpoons, and many other uses. The horns and hoofs they saved to make into harpoon points, fish hooks, and needles. Then when all was completed, a great dance was held at which each participant was required to eat a 'hunk' of tallow. After this all returned again to Quillayute and James Island."

3. THE WHALE TOTEM MYTH

It was in the long, long ago. The medicine man rose and addressed the assembled whalers in sonorous, convincing tones: "Indeed, I wish to talk to you," he began. "For months and months I have mortified my body and made my spirit strong for the coming whale hunt. And the whales are ours.

"In my night visions last night I saw a great totem pole of many days'

journey in length. This pole also had a large whale carved on it crosswise near its further end—a carving which, too, was many days' journey in length. I was in a deep sleep when it appeared to me. It stood on the earth on the ocean beach of the great waters; but it did not stand straight up and down. Instead, it leaned over the sea at a low angle.

"As I was looking at it, the elder thunderbird flew through the heavens, flapping his suspended feathered wings, thus producing the dreadful 'thunder noise,' as he opened and shut his eyes, making the lightning flash thereby.

"At that instant Kwatte, our god, stood before me. At first he was as small as a mosquito, but as I looked at him he grew in proportions till his huge form shut out the eastern sky and closed out the light of the rising moon. He was bird, beast, fish, and man all combined in one form.

"For a moment after he appeared there was a raging wind, a rushing, hissing sea, and a quick moving of the earth in an up-and-down direction. Then all was still, save that Kwatte was speaking to me in a calm, but commanding voice, saying: "Go, climb the pole."

"I was in a deep sleep, but I obeyed. I climbed out, far out to the edge of the world on this totem-pole ladder. There I saw many, many things. There I saw the feet and great talons of the rainbow-bird. I also saw the great killer-whale swimming here and there. Down, down into the very deep I also looked. There I could see the fishes of the sea and great schools of whales. I also saw the great band that holds the waters on the earth in place.

"As I was looking, Kwatte again appeared before me and said: 'This is your "tomanawis." The whales you see are yours. Go, kill them. The feast is set."

"Again I heard the 'thundernoise' and saw a great piercing light across the western clouds. Then I awoke.

"Tomorrow with the coming of the light, we will set out to cheat the thunderbird of its prey. The whales are ours. My 'tomanawis' (witch power) will kill them for us. Tomorrow——"

A deafening, roaring shout, followed by a song which imitated the shrieking, howling wind, closed the meeting.

Then the next morning at an early hour all the whalers pushed their completely equipped canoes out into the surf; and in that one day ten whales were killed, in that one day whale oil and meat enough was secured to last the tribe for years. Then there was great feasting, followed by the loud, clamorous thunderbird songs, accompanied by much pounding of shakes.

4. THE RAVEN AND THE DEER

In the long ago Raven and Deer lived in one long house, Deer living in one end of it and Raven in the other.

Raven was hungry and decided to get some meat by treachery. So he said to Deer: "You be a mourner as in the old times."

"But," objected Deer, "No one has died."

"You be a mourner for the fun of it," insisted Raven. "You be a mourner anyway. Take this blanket and place it over your body and head so that only your eyes are uncovered. Then go about mourning for the people who have died in your family and mine in the long ago.

"You go around through the timber up around through that low patch of

ground. Then go through that salal berry thicket to the top of that steep cliff yonder in the far distance. When you reach its top, come over to this side of it and sit close to its perpendicular face on this side. Sit with your face this way, facing the valley, and there sit and mourn till the going down of the sun. "If you hear anything behind you in the brush or hear the brush crack, pay no attention to it. Keep your face turned this way and keep up the mourning for the dead, as a mourner always does."

Deer did not care to do this thing, but Raven kept coaxing him till at last he went.

He put the blanket over himself and went around through the brush, as requested, singing: "A-ke-da-ah, a-ke-da-ah, a-ke-da-ah" (my heart hurts me, my heart hurts me, my heart hurts me).

Reaching the cliff, he seated himself, as he was instructed to do. He then covered up his face with his hands and blanket and continued his mourning song: "a-ke-da-ah," etc.

Tricky Raven was following him, and when he had seated himself close to the edge of the cliff, he slipped up through the brush to him from the rear.

Deer did not pay any attention to the noises he heard in the adjacent brush. So Raven slipped right up to him. Then with one big shove he sent him rolling over and over down the cliff. He then went back to his house, saying, "Wife, get the basket and carry the meat home, for I have killed Deer."

He took his big knife and his wife took the basket. They went to where Deer was lying stretched out with head thrown back, as if dead; but he was still breathing.

The blackbirds, crows and many other coast birds had come to share the meat, too. They were hungry; they always are. They were jealous of Raven, for he always wants all, if he can get it.

Raven took his knife. He prepared to cut the animal open down the breast. He bent over to plunge the knife into the flesh.

Crow was sitting close to Deer's ear and also knew that he was alive. As Raven bent to give the thrust, he whispered to Deer: "Kick him with your hind feet."

And Deer did kick. He struck him a terrible blow with both hind feet and broke his nose.

In terrible pain, Raven then ran into the brush, cackling and crying. Cackling and crying, he ran to his house.

Deer then jumped up and leaped and jumped through the brush to his home, for he had only been hurt a little by the fall.

Raven did not get any fresh meat that day, but he did get a broken nose. You can see the place on his nose today where Deer kicked him.

5. RABBIT, GOOSANDER DUCK, and EAST WIND

Rabbit and Goosander were each fishing in the river in his own canoe and were dragging a drag net between their canoes, the way the Indians seined in the olden times. At that time there was a long line of canoes, in twos, fishing this way as they went up the river. Among these fishermen was East Wind. He is always cold (in the Olympic region) and was then making the river and country cold all about him, as he always does.

In the olden times the Indians carried a quantity of live coals in the front end of the canoe, and a mat of sand, to keep them warm, or by which they could warm themselves when necessary. Rabbit was cold and was sitting over one of these fire mats warming himself.

For the fun of it Kwade, the goosander duck, would so hold his pole with which he shoved the boat upstream over shallow places, that the water would drip off it, and, running down Rabbit's nose, would freeze there. East Wind, who then had a huge, thick, solid ice hat on his head, also came by in his canoe. As he came alongside Rabbit's boat a fierce cold wind blew on the latter and made his face more cold from the water that was dripping from Goosander's boat pole.

Quickly he seized his own boat pole, and before East Wind noticed the move he struck the ice hat and knocked it from his head, breaking it into thousands of pieces, as it disappeared beneath the surface of the water. Since then Docas, the rabbit, has been the symbol of the South Wind. And to this day East Wind flees when South Wind comes.

6. THUNDERBIRD IS BEATEN IN A SPEAR-BALL CONTEST

Once Thunderbird invited all kinds of animals, devil fish, rock cod, rock clams, salmon, etc., all the fowls of the air, and all the beasts of the land to come to a spear-ball contest at his home, stating that he was going to make fun for them and also dance before them. All came as invited, all bringing their spears with them. When they had all arrived he went to one end of his long room and had his guests sit at the other end.

He had something like a round ball in his hand. This he rolled toward the visitors, who he asked to spear it with their spears; but just as they were in the act of hurling their spears it lightninged; that is, a lightning flash came out of the ball. This prevented their hitting it.

"You have beaten us with your medicine," spoke up Crane. "Now you contest with us. I have a magic ball myself. I will roll it to you and you see if you can hit it with your spear."

He rolled his "tomanawis" ball toward Thunderbird, who made ready with his spear; but just as he raised his arm to make the thrust a fog enveloped everything in the house so that the inmates could not see each other. Consequently Thunderbird missed the ball. Being outdone, and Crane now being recognized as the hero, Thunderbird became enraged and sought to kill his guests; but all succeeded in fleeing from the place except slow-moving Devil Fish.

Being unable to escape, Devil Fish hid himself behind a board partition, thinking that he was safe there from the wrath of the king of the skies; but he was discovered. As soon as he was found, Thunderbird took him by the hair of his head and pulled all the hair out.

"Don't kill me right here," begged Devil Fish. "I have lots of blood and will drown all your people with it. Put me over there where the sea is. You can kill me there. I will stand up there for you to kill me." So Thunderbird took him to the ocean and made him stand up to be slain, but no sooner had he stood up than, quicker than a flash of lightning, he hurled himself in the mud under a big rock down in the deep waters.

7. THE WHALE-BEAR MYTH

The whale used to be a human being. At that time at a wrestling match between the sea animals and those of the land, Bear threw Whale down and scratched him on the throat and breast. These scratched places are the slits through which whale now strains the water out of his monstrous mouth.

8. A MYTH ABOUT RAVEN AND EAGLE

In the long, long ago, before the transformation occurred that caused things to be in the form and state of being as they are now, at that far-off time when all things of earth were human beings, Raven was a strong Indian. His wife was the crow and they lived on that point yonder that projects out into the surging surf to meet the Quillayute Needles. Raven and his wife could never get enough to eat. Furthermore, as they were lazy to the utmost extreme, they consequently lived solely by others' labors. In fact, they stole everything they could and also devoured the bodies of all unburied dead. Not only that, but on account of their unsatiated hunger, they turned canibals and went to killing human beings. Moreover, as they had very strong beaks, they were a terror to the whole country; for with them they tore in pieces and devoured everything they could find.

At about this time Raven met Eagle and they had a savage fight. Raven got whipped and always had great respect for Eagle thereafter; but, as the latter had a son, he planned, through trickery, to "get even" with him. So with his "tomanawis" he caused the son to die (faint), then come to life again.

Eagle knew that Raven was a medicine man. So in dire distress, lest his son should permanently die (faint away and not revive), he went to his house and asked what he should do to have his son recover.

This was Raven's opportunity. So he sneeringly answered: "Let him faint away till he is dead, dead, dead. Then take him out on yonder sand pit and dig a shallow hole and bury him in it so that he may undoubtedly be dead." Then as he gave a diabolical smile and shrugged his shoulders, he further remarked: "Things to eat are scarce," meaning that he would go and dig up the body and eat it as soon as it was interred.

Eagle knew that Raven was making fun of him. So he returned to his home in a rage, vowing that as that black-coated person also had a son, he would get even with him, too.

In a few days Eagle went out fishing in his canoe with that end in view and, being a good fisherman, he soon caught a load of fish. Then after making the catch, he managed to go home just as Raven, who was sitting in his front yard, could see that he was carrying a heavy load and that his wife was also laden with sea food. Upon arriving at his house, he built a fire, upon which he placed a lot of decayed stuff to make a great smoke and thus further attract Raven's attention. Moreover, all his schemes worked as he had planned.

Raven saw the smoke ascending to the clouds where Thunderbird lives and, being hungry, he fell into the trap. Whereupon he went at once to Eagle's house and saw all of Eagle's family eating halibut. Even the son who had been having fainting spells was sitting up eating; and—there were baskets and baskets of halibut everywhere about the place. Surprised, he looked at the fish for a few moments, then raising his beak, he asked: "How did you get so many fish? They won't bite for me."

"It's this way," replied Eagle, "I use my son for bait. I attach him to the yoke-shaped hook-stalk. Then around him I place my hooks. The whole I then sink gradually downward to the bottom of the sea or till the nibbling ceases. I know then that a fish is fast to each hook. My son, you see, catches the fish. They nibble at him and get caught on the hooks. I then draw up the line and I have lots of fish at a haul. I got a whole canoe load in a quarter sun."

Raven was surely fooled, believing all that was told him. So without waiting to hear more, he flew off to his home and told his wife all about Eagle's big catch and how he had successfully used his son for bait.

"You won't use our son that way!" broke in the mother on his enthusiastic declarations.

"Yes, at the coming of the sun again our son will be the bait. You shall go along and witness the big catch."

"No, no, not our son!" strenuously objected the black-coated mother. "Eagle is tricking you. I know he is fooling you."

He was obdurate, notwithstanding, and the next morning he and his wife and son went out to fish as planned. When they had reached the "banks" he took the screaming child and, after having tied hooks all around his body, lowered him to the depths by a kelp rope which he had tied around his waist.

Down, down he went, and as he thus sank and strangled, he struggled and jerked on the line; but his weight bore him on downward and his foolish father let him go on to his death, believing that the struggling, jerking on the line was caused by fish's nibbling on the hooks. Down, down he went till he reached the cozy bottom and then his life left him.

With the going out of his spirit, the struggling consequently ceased, and Raven then hauled up the line, as he called to his wife: "Come here, Crow. Come quickly! This line is heavy! I've lots of fish! The scheme has worked fine! Come quickly! I can see them coming up!" But, oh, the horrid sight when brought to full view! Even Raven turned his head and wept. Up came their son with outstretched, stiffened hands! His soul had gone to the shadow land; but not a fish was caught.

They put the lifeless body into the canoe and paddled homeward, as the woman tore her hair and shrieked: "Ah-ke-dah, ah-ke-dah" (my heart aches, my heart aches!), exclaiming the while: "I told you so! I told you Eagle was tricking you! I told you so!"

As they were landing with the corpse, Eagle was passing through the yard, apparently by chance. So on noticing his neighbor, Raven called to him: "Friend Eagle, I have followed your instructions and now our son is dead. What shall we do now?"

"Put him beneath the sod," retorted Eagle, "Things to eat are scarce."

Following the funeral, Raven and Crow, his wife, had "a great trouble." So he left her and stole the daughter of East Wind to be his wife from then on. But East Wind, who goes everywhere, as you know, sought the earth over and at last found Raven hiding in the thick woods where he was concealing his stolen wife. A fearful engagement of many days' duration followed, in which East Wind, who owned all the land of the whole earth, being then the richest man in the world, sought to drive Raven from his possessions and

compel him to live in the sea; but this fiercest of fights was a drawn battle. So after the unpleasantness was over, a compromise was made by which the latter was to keep his new wife; but the question about the land was left unsettled, though the former had already parceled out all his then land to other people.

Of course, Raven could still have plundered his living off other people as he had formerly done; but since leaving Crow, his first wife, he wished to be a more respectable personage. So, after considerable persuasion had been brought to bear on the subject, Eagle and East Wind finally decided upon a plan that would give him some land which he could use as his own.

Prior to that time, the ocean and the land always remained the same, exactly the same; there was then no coming in and going out of the sea waters as now. East Wind therefore caused the ocean to move out and back over a strip of shore land once in every twenty-seven days, the thus-newly-made-land being given to Raven. This, however, did not satisfy him, for half of each month he would be compelled to starve. So he again went to East Wind and they had another quarrel, after which another compromise was effected, as a result of which the tide recedes from the flats twice every day and night—a change which was satisfactory to all. For by this arrangement, the ebb and flow of the tide was inaugurated as it is today; and ever since that time the raven and the crow families have been able to find sufficient food of sea things that have been left by the "going back" of the waters on the thus bared, narrow strip of shore land.

9. A HOH VERSION OF THE MYTH ABOUT RAVEN AND EAGLE

Baayak, the raven, went over to Eagle to get something to eat. When he got there he was surprised to see so many eatables, so many fish and other salt-sea things. Said he to Eagle: "What do you use to catch the fish you have?" Eagle replied: "Do you see my son there? He is what I use to catch fish with. He is the fishhook."

Baayak went home at once. As soon as he had arrived at his residence he called his family together and said: "I have been over to Eagle's house and saw all the fish he has caught, a very great number, I assure you." Then turning to his son, he said: "Eagle uses his son for bait and hook and I want you to be mine."

The next day Baayak went fishing, his son to be used as a fishhook. As they were nearing the fishing grounds Eagle flew by and said: "Don't pull up the fish line till all the hooks are full."

When all was ready, Baayak hooked his son on the hooks for bait and let him down into the deep. Then after he had lowered him for quite a little while he commenced testing the line, pulling on it now and then to see if the hooks had anything on them. At last there was a bite, there was a fish. There was a struggle. A fish had swallowed his son and killed him. He then found by testing the line that there were quite a lot of fish on it. So he drew it up. As soon as the hooks reached the surface, he found that his son was dead. Baayak's wife, who was present, then exclaimed: "That is just what I thought! Eagle fooled us!" They then went home crying and bemoaning their dead son, saying, "Glaa-wa-kus tel-a-bu-e-e-e-e-ha-ha" (Glaawakus was their son's name).

Arriving at their home, they buried their son. Then just as they were leaving the grave, Eagle flew by and mockingly said: "Did you catch any fish?"

10. THAT ARROW LADDER

In the long ago, when all things were human beings, Whale was the biggest person then as he is the largest animal now. His daughter, Miss Porpoise, had just been admitted into the Tsyuk dance order, and he was going to give a great "potlatch" (give-away feast) and dance in her honor.

While they were waiting for the women to prepare and spread the feast, they had contests of various sorts. There were wrestling matches between Beaver and Otter in which Beaver got the best of Otter by tripping him with his tail. Then there was a lifting contest between Cougar and Sea Lion which ended in a draw, followed by a running match between Clam and Snail, in which Clam won just by a foot (his own foot).

Just as the latter contest was about to be finished, Mr. Whale himself appeared, having gone to the woods some time previously. He was carrying a large yew-wood bow which was greater in length than any tree now growing. Its bowstring was twisted whale intestines; and the arrow he carried to be used with the bow was many, many paces in length.

Reaching the curious throng, he said: "My brothers, this is the great day of my life. My daughter is now 'first class,' all but giving the feast part of the ceremony which is now in preparation. Today I am happy. You have had your contest in wrestling and other sports. Now I have a shooting contest for you. To the young man who has strength enough to stretch this bow and shoot this arrow I will give my daughter in marriage. That is the prize. Here is the bow and arrow. Try your luck. "Thus saying, he threw the great piece of wood down with a thud and seated himself on a near-by log to await the outcome of the shooting contest.

No sooner was the challenge made than accepted.

Bear was the first to try his skill. He bent his back to lift the log-like bow, but he could not raise it a finger's width above the ground. Then he tried to lift just one end of it and even this he could not do. Then as he retired, the lookers-on jeeringly laughed at him.

As Bear sat down, up jumped Cougar, as he laughingly remarked: "Oh, that's nothing. I can shoot that arrow." But he could not raise the bow a hand's breadth above the ground. Then giving up, he declared that no one living, except the whale, could shoot with that bow and arrow and that any one was a fool to try it.

At this moment up sprang Rabbit, jumped about the bow and over it for several times, chewed on the bow spring an instant and then hopped away into the near-by bushes, as everyone laughed loudly. Then, just as the laughing at Rabbit was about to cease, all eyes were turned upon Ch-cho (the Winter Wren). You know he is a gay fellow and always ready to go on a courting trip at any and all times. "Mr. Wren," shouted nearly everyone present, "try your luck and win the prize. It would do you good to win this young lady. You'd settle down and be more than the dandy that you are now. Try your luck."

Besides being very handsome and a sort of coquettish fellow, as was insinuated, Wren, then as now, possessed a very violent temper. Quickly he threw

himself into a passion and began to strut and flutter and hop, as he muttered over and over again his scolding, clamoring, abusive "Cho-cho-cho-cho." Then after he had thus fluttered about for a considerable time, he began to call his "tomanawis" (witch-hypnotic-supernatural powers) to help him avenge himself in the eyes of his tormentors. Moreover, in those days he was a great medicine man and his "tomanawis" was of the powerful kind.

His "tomanawis" came to his aid, and soon, though small as he was, he went to the great bow and the large arrow. Around and over them he fluttered for several minutes as he was adjusting his witch power to his use. He then quickly flew down beside the log-like bow and, to the amazement of all, raised it and put it in position for shooting. Across it he then placed the large-sized arrow. Through his "tomanawis" powers, he raised them so that the arrow pointed to the center of the dome of the heavens. For a moment he stood there as he steadied his muscles and took aim. Then "zip!" and the arrow sped forth into space and out of sight. Next down came the bow to the ground with a thud, and Wren fluttered off into the bushes as he uttered his abusive "Cho-cho," and at the same time stated that he did not wish the prize, for he considered Miss Porpoise too homely to become his wife. Under ordinary circumstances this refusal of Wren, couched in language as it was, would have brought serious trouble, but in this case his sayings were not noticed, for everyone was looking upward to see what had become of the ponderous arrow.

It went up, straight up out of sight, and it did not come back to earth. At first all were agitated lest it fall on them and crush them. Then wonder took possession of all. Skyward they kept their gaze fixed. Searchingly they scanned the heavens. Yet no arrow could they see. Of the assembled throng, no one had eyes powerful enough to see so far into space.

Suddenly it was discovered that Snail had not attended the "potlatch." Furthermore, it was known that he had very penetrating, powerful eyes. So Eagle was sent to bring him to the place of meeting. Now Eagle was always a thief as now. So, finding Snail asleep, he plucked out his eyes and appropriated them himself. That's why Eagle has such sharp eyes and Snail has none; Eagle is using Snail's eyes even in our time.

After procuring the eyes, he soared back to the "potlatch" hall and there, in the front yard, he began to look for this arrow that never came back. He looked and looked with the stolen eyes and finally saw the end of the arrow as a very tiny speck. It had had its dart end driven through the lower surface of the blue-above and there it was sticking with heavy end suspended.

On seeing the arrow's suspended end, he called Wren to him and through the appropriated eyes, he showed him the arrow (for the time being they were using Snail's eyes as we now use field glasses). Then as soon as the latter saw the arrow sticking high up in the sky, he seized the powerful bow and dispatched an arrow upward using the large, suspended end of the arrow already up there as a target. So well did he aim that he drove the pointed end of the arrow into the center of the target, and it, too, stayed up there in that far above. And thus did he continue shooting arrows till he had caused one arrow to be suspended below another till the arrow-column reached from earth to the sky, a ladder from earth to heaven.

Then curious to know what was up above, the lookers-on began to arm

themselves and climb this improvised ladder. Up, up they climbed, hand over hand, bear fashion. It was in the afternoon when they began to climb, and days and days did they climb. Finally one night they reached the place of heaven. The first arrow had punctured the firmament and beside it there was a great hole up through which they all climbed. It was night when they got there, and as no one was expecting an enemy in that country—all were either sleeping or were at their night's labors, such as fishing and trapping—they succeeded in crawling into heaven unmolested.

On arriving up above, the earthly host scattered about to see what was to be seen and also to find something to eat. Some of them went to the fish traps, which they found in operation, and there they saw huge piles of fish, which they stole; but when they tried to eat them they found they were only hard-wood knots. And at about the same time Skate (fish) was skulking about in the dark in the vicinity of the house. The inmates of the place, of course, did not know he was there. So a woman, in throwing out her dishwater, threw it on him, and since that time his flesh has never tasted good. Others went to see the beautiful bright star that shines in the evening and morning skies, and to their surprise they found it to be a red, sore-eyed old man whose wife was a daughter of earth, a young woman he had deceived by the shining eyes.

They all camped in a meadow, or rather huddled together there; but such a place! In front of them was a great river; and in the adjacent forest the trees were no larger around than one's wrist. The salmon berry bushes, too, were only four fingers high and the fruit was so small that one could scarcely see it. The squirrels and rabbits of that region were also less than a finger joint in length; but the men of the place were large and strong, for they lived on the fish of the streams.

When our people camped there, it was very cold; but across the river they could see a fire. So Mink swam over and stole a few gleaming coals, put them in his rain hat and recrossed the river with them; but his act was discovered before he had hardly crossed to the side of the people of earth.

Instantly the heavenly warwhoop could be heard on every side. The river soon swarmed with canoes and in an incredibly short time a terrible battle was on. The people of earth were defeated and soon were trying to climb down the ladder in panic order; but the worst was to come. Before half of them were down, the ladder became unjointed and fell to earth, crushing all who were on it, and the other unfortunates are still up there in the starry vault, for they have never yet been able to get down to their old home.

After the ladder fell there was "great trouble" in Whale's house. Cougar blamed Whale and Wren for all the trouble, and soon a fight was on. Cougar scratched Whale on his lower jaw and caused great slits, alternating with ridges, to be formed. You can see them on Whale's chin and breast to this day. Finally, to escape with his life, Whale took to the sea with his daughter, Miss Porpoise, where they have lived ever since. At the same time Wren, who was also very much scared, made his body so small that he escaped through a knot hole in the lodge. Then to the brush he betook himself for protection and has been a small, skulking-about fellow ever since.

The people of earth who were still up above when the ladder became disjointed are there still. Some were made stars. Others were more powerful than their neighbors and now are ruling chiefs in their own respective sections,

but none have ever been able to get back to earth. The great snake (the Milky Way) which encircles the dark sky, Big Elk and Little Elk (Great and Lesser Dippers), Cougar, Bear, the Smelt Dip Net, Whale's Chair (Cassiopeia's Chair), Skate (fish), Salmon, Wren's Meat Tray (Job's Coffin), these and many more, you can see any clear night. Rainbow is also still up there. We see it in the daytime. As you know, it is a huge bird; and the bright colored arches we see are its legs. Its feet are armed with powerful talons with which it often seizes firm hold upon the earth; but its large body, the clouds, is in the sky, and though it often struggles hard, it cannot draw itself down to earth by its gripping feet. In the long ago after this rainbow became one of the heavenly hosts, it also gave birth to a child, a daughter of one of the children of earth, and every now and then the mother comes forth with her child, the secondary rainbow, and scours the earth to see if she can see her child's father; but to this time she has never seen him since that unfortunate day. Then when she cannot find him, she and her daughter meet and cry. You can hear their voices in the mournful wind; the rain is their tears.

11. A MYTH ABOUT TWO YOUNG LADIES, WAR IN HEAVEN, AND HOW THE GREAT BEAR AND THE LESSER BEAR CAME TO BE STARS.

Two young ladies were digging fern roots on the prairies. Night came on and they retired, but did not go to sleep. As they reclined on their mats they talked and talked the hours away. As they were conversing, one of them looked up into the heavens and said: "I wish I had that bright star. I would marry him."

Hardly had the words been spoken when two suitors from the starry vault came to visit them. As soon as they came, one of them said to the lady who had made the wish: "I am the person you love. Come with me." So he took her with him.

He tied her hair in a band like a turban around her head; and across the vast space they soared till they got above. But when they arrived there the young lady was very much disappointed, finding that her husband was a very decrepid man with "awful" sore eyes, the soreness of his eyes had given the red glow in the sky that had attracted her attention. Said she to him: "I thought you were a young man. Now I find you are old and almost helpless. The next day she died, having grieved herself to death.

The people of earth made up their minds at once to go above to avenge the death of the girl. So all the animals of the earth and sea met in one place. Among these was one of the strongest animals of the woods, Tatakweal by name. This strong man told the animals, all the creatures of the earth, to band their bodies with war paint and get ready for battle.

This Tatakweal had a big bow, made of a whole tree. It was quite a curiosity to every one, and while the people were engaged in the war preparations, various ones of them would examine it. Whale tested it first. Then Bear tested it. He bent it easily; but many of the other creatures present could not bend it at all. Then they began to jest each other about it. At length one of them pointed his finger at Winter Wren, Chocho, in fun; "Chocho, you are too small to do anything. You can paint your cheeks but you cannot do anything else."

Another creature spoke up and said: "Don't let us fool with this bow any longer. We have been here too long already."

At this juncture Chocho jumped over to the bow, and, taking it in his claws, he easily bent it. Just as he was doing this marvelous act for one so small, another animal said to him: "You are too small to do anything. You have no more power than a fish's brain." But the little bird bent the bow, nevertheless. Then as Chocho prepared to pull the bow string he sang over it over and over again: "I am going to shoot to heaven. I am going to shoot to the heavens."

He carefully fixed the arrow, drew the bow and shot the arrow out of sight to the very heavens and said to the assembled peoples: "Look above and see if you can see the lower end of the arrow."

All looked but could not see it, none but Snail. He could easily see its lower end up in the sky, up above the moon and sun. Just then Eagle and Hawk came by and, taking out Snail's eyes, they appropriated them themselves. That is why Eagle and Hawk each has sharp eyes and that is also the reason why Snail has no eyes: Eagle and Hawk have his eyes.

Tatakweal resumed the shooting as soon as the end of the arrow was located, trying to shoot the lower end of the arrow. This he finally succeeded in doing, firmly fastening the arrow in the end of the one above it. This he continued to do till he had an arrow ladder from earth to heaven. Bear went first, then Flounder. They went up to battle with the people who had taken the girl.

When they got to heaven they found it a very cold place. So some suggested that a fire be made. Robin was delegated to make the fire. He went to one of the houses of the people of the skies to get some live coals. When he got to the house he said: "We are cold." The lady of the house looked at him a few seconds and, admiring him, asked: "Are there lots of robins down below?" Robin answered: "Don't say anything to me about robins." He stopped there because it was warm. He could not make up his mind to leave the fire. He never came back. He even kept himself so close to the fire that he scorched his breast; that is why it is red, the color of the fire.

Beaver was sent to another place to try to get some fire. He crossed a river close by a stockade-like fish trap that spanned it. On the upstream side of this fish trap there was a platform from which the people of heaven fished. One of these people was drawing up his line. Beaver swam along the trap but avoided the net at the opening in the "stockade." Unluckily, however, a whirlpool drew him into one of the nets just as he was nearing the shore on the opposite side from where he started. In a moment the fisherman drew him up to the platform. It was daytime. The fisherman got his "tomanawis" fish club and hit Beaver twice with it. Seeing that while in a net there was no chance for escape, Beaver pretended to die. The fisherman then took him out of the net and brought him to his home.

As soon as the people up there saw him they hallooed across the river and asked the people of earth if they had animals like that down below. But they answered not a word. They did not want to say they had lots of such animals down there. They did not want it known that Beaver had come from the mother earth to them.

The people of the skies got ready to skin Beaver, but before they had time

to cut the skin, he jumped over the fire and, taking some live coals in his hands, escaped to his people on the other side of the river. Furthermore, when he got to his camp he found his people ready to go over to the other side of the river to fight. They were ready to join battle with the people of the regions above.

Seeing that there was going to be a battle, the up-above people went to where they kept their arms to see if they had bows and arrows there. To their chagrin they found that the mice had knawed the bowstrings to pieces and that worms had eaten the wood of the arrows and spears. So they found themselves totally helpless before the men of earth.

The people from below crossed the river. They engaged the enemy. They prevailed on every hand. They killed all the people who came out to oppose them. The up-above people all perished in the battle, all but one. This one was a very strong man and knew how to fight. He escaped and went up into the second heaven to get aid from this heaven.

As the victors in the battle just fought were preparing camas for dinner, they heard the people from the second heaven coming. So they shook the ladder that extended from the first heaven to the second. Soon the ladder broke, and all the second-heaven people fell down to the first heaven, but they could still fight. They fought with a vengeance, even though they had fallen so far. They defeated the people of earth and drove them out of heaven. Down the ladder back to earth came all the people, all but Great Bear and Lesser Bear and a few other animals that still remain in the heavens. The ladder broke before they could all get down, and since that day our people have not ventured beyond the confines of mother earth.

12. WHY THE MOLE IS BLIND

Once all the animals of the earth met for a great shooting match. They were to see who could shoot an arrow the highest, which was to be determined by a man's walking back and forth between two posts. The highest shot arrow, of course, would require the longest walk.

Beaver shot first, and the walker had hardly started when the arrow fell to the ground, as everyone laughed. Elk then shot and did a little better, the walker making one walk between the goal posts. Bear next shot, followed by Otter. When the next one tried to shoot there was a big laugh. This one was Skunk, and he could not lift the arrow and bow off the ground. Shrew shot next and his shooting was a surprise, for he shot the arrow to the clouds. Mink then came forward, as everyone yelled: "Here's our shooter. He wins."

He took the bow and carefully examined it, then straightened the arrow and tested the bowstring, as everyone laughed, "Oh, oh, oh, oh." He carefully placed the arrow and sighted, then threw the arrow as far as he could. He then took an arrow from his own quiver and placed it. "Whang, zip," it went. It cut a wide hole through the clouds as it left a streak of blaze behind it. It sped heavenward like a shooting star, going up instead of down. All gazed up, up into the sky till it disappeared; even the goal man forgot to walk between the posts. Then all waited for its return, but it did not come again to earth. A day passed and it had not returned; and not an animal could see it in the sky. The birds were then called to try to find the arrow; and one after another searched the heavens, but could not locate it.

Mole had not been at the shooting match, but was back of a cliff digging a house. As the birds were flying about, they flew past where he was working. On seeing him, they told him about the arrow's being shot out of sight. So he quit his work and went to searching the heavens for it.

With his first look he saw it. Mink had driven it into the ceiling of the heavens and there it had stuck. "Yonder it is," he simply said, as he pointed toward it. "If I were only a bowman I could shoot it and bring it down, but as I dig in the earth I cannot shoot so far."

"Let us have your eyes," shouted a dozen voices. "Lend us your eyes and we will shoot it with our strong arrows."

Crane seized the eyes and shot first; but his arrow did not get near the arrow in the heavens. Hawk next tried and did no better. Then Eagle came forward, drew the bow very carefully and shot. The arrow went out of sight and was gone a long time. It then fell on Turkey Buzzard's neck and head and so hurt him that he bled a great deal; and since then he has always had a featherless, red head and neck. Eagle then tried again and again, but finally quit.

As he laid down the bow, he saw Cho-cho, the wren. On seeing him he said, sarcastically: "You are always boasting what you can do. Now is your chance to show your skill. Here are Mole's eyes. Now shoot that arrow in yonder sky."

Wren took the bow and arrows, and, examining them, threw them down, saying: "No one could shoot to heaven with those." He then went to the woods and cut down the largest yew tree in the region. This he made into a great bow. He then cut down twelve of the next largest yew trees he could find, each of which he made into a single arrow which he pointed with a flint head. These he carried to the contest ground; but, being tired from carrying them, he rested a day.

While he was resting, all the animals and birds came to see the big bow and strong arrows he had made and to watch him shoot the arrows. But not one of them could lift the bow or one of the great arrows. Even Eagle and Great Bear tried it and failed.

As the sun rose on the following day, there was a big stir. Wren took the big bow and great arrows and prepared to shoot. He placed an arrow and raised the bow skyward, then dropped it, for he had forgotten to use Mole's eyes to see through. Consequently, he could not see the tiny end of the arrow in the sky. He got Mole's eyes. Again he lifted the bow. "Whang, whiz," went the arrow. He shot eleven arrows, then fell exhausted; but he had done his work. The first arrow struck the arrow in the sky and drove its point into the end so that it remained fast, dangling in space; and each successive arrow was driven into the end of the last dangling arrow.

One arrow more was needed to span the space between earth and heaven. The arrow was there, but now that wren had fallen who would shoot it? Every one asked Great Bear to try his hand and he finally decided to try, though he had even failed to lift one of the arrows the evening before.

He took Mole's eyes and used them to see with, though he did not need them at all, as everyone could see the end of the last arrow that Wren had shot. With great effort and after many attempts, he lifted the bow and arrow

Then by a lucky shot he hit the end of the last arrow and his arrow stuck fast. Thus was an arrow ladder made from earth to heaven.

Everyone then wanted to climb the ladder at the same time. Up, up they went with a rush! Great Bear was the first to reach the starry heights over it, closely followed by others. Everything, in fact, went well till a very large, fat woman tried to climb it. She got to the ninth arrow, Then became nervous and could neither go up nor down. She trembled so badly in her fright that she shook the whole ladder from earth to heaven. The eleventh arrow came unjointed from the twelfth and it and the ten arrows beneath it fell back to earth. And where the woman fell there is now a great hole filled with water called the Pacific Ocean.

Many people of earth were in the heavens when the ladder broke and they are there still. One of these is Great Bear. You can see him in the northern sky any clear night. That one arrow is also still there in the sky. Its end, which we can see, is the North Star. And poor Mole! Great Bear took his eyes to the starry vault with him; and, as he has never returned, his race must be without eyes for all coming time.

13. A MARRIAGE MYTH OF THE LONG AGO

A long time ago two girls went to the prairie to dig ferns for flour. As they went they passed by an open space in the woods where the decapitated head of a young man was suspended on a pole-stake. As they passed it, they stopped and looked at it several minutes. Then as they were in the act of leaving the spot, after they had conjectured much on how he had met his death, the younger lady remarked: "I wish that man had been my husband. He has a good looking face. I wish he could be my husband now."

They went on to the prairie. Throughout the livelong day till the sun sank into the western sea they dug fern roots and piled them in piles to dry. Consequently when night came they were very tired. So they spread a mat on the fern leaves in an old Indian lodge near where they had been working. On this they both reclined and were soon fast asleep.

Soon after they had gone to sleep, there came a rap on the wall outside the house. The noise woke the younger girl who immediately asked, "Who is there?"

"I am here," came the answer. "I am the man you want to marry. I am the man whose head you saw on the stake this morning. You said you wished to marry me, and now I have come for you. Come with me to my home and be my wife."

"I am your wife," responded the young lady from within the house. "I will go with you." Then waking her sister she told her that her husband had come for her and that she must go with him to his home at once. She also begged her parents to forgive her for leaving them and asked her sister to so tell them.

The young lady and her husband went to the seashore near where our (Quillayute) village is now. There they took an ocean canoe and started on their journey to his home. It was many, many miles across the far, deep ocean. For days and days they traveled, sometimes with favorable winds, sometimes with contrary winds, in which case they had to use paddles to make headway in the desired direction. At last they reached the opposite

shore near the husband's home. There they landed and drew the canoe ashore and placed it in a secure place above tide. They then carried the things they had brought with them and also placed them in a secure place.

Then said the husband to his wife, as he filled her carrying basket with things: "You climb up that bluff yonder and when you get to the top of it you will see a little prairie before you. To the left of you you will see a little house. That is our house. I own all the country around here. There are lots of elk here, and tomorrow I will kill one and we will have a feast." So saying, they started to climb to their new home, the woman with the heavy pack on her back, the man empty-handed, as is the Indian custom. When they got to the little prairie, the woman found before her one of the most beautiful spots she had ever laid her eyes on. And there were just lots and lots of elk just like great herds of cattle now and just as tame.

Being tired and worn out from the labor of their long journey, they ate a lunch of dried fish and some dried berries, then retired for the night. The next day they arose early, killed an elk and had fresh meat for breakfast. After breakfast they cut some of the meat into strips and hung it over the fire to dry for use when the elk would be poor in winter. They then walked and strolled about to see the many beatuful things in the vicinity of the home. At night they again returned to the lodge and slept soundly till the rosy morn returned.

For many weeks they passed a pleasant time together. Then the husband went away one morning, leaving the woman all alone, for no one else lived in the immediate vicinity where they had their house; the woman had never seen any other human being in the region but her husband. On the second day he returned. In a few days he went away again and stayed away the same as before. A few days later he again went away and this time he stayed two days and two nights, never telling his wife why he went away or when he would return. Again and again he went away and did not come back for a considerable time, each time increasing the length of his absence. Once he stayed away ten days. Then, finally, he went away and never came back. Thus was the poor woman left alone in this isolated place. What was worse she was in delicate health. Thus deserted, she pined away, and got "all bones."

Finally, one day when she was almost ready to die, there came a rap at the door, and a young man entered the house. Both were surprised; the woman thought at first it was her husband returning, and the man was surprised to find a woman in the region. He exclaimed: "How did you get here? No one lives on this part of the earth but my own family. We live at the other end of this prairie. This place belonged to a relative of mine, but he has been dead a long time. How did you come to get here?"

She told him how when she was a girl at Quillayute she and her sister had started to dig fern roots on the prairie and that on the way to the fern patch they had seen the man's head extended in air on a pole, and that on passing it she had wished to marry the dead man, or wished she could have married him when alive, as he had such a handsome face. And that night he had come and got her and married her as she had wished, that they had crossed the great, mighty ocean to this place, and that for a time they had lived happily there. Then the husband went to being away from home for a

day or two at a time. Once he stayed away ten days. Finally he went away and never came back. What was she, a poor woman, to do?

On hearing her story, the young man said: "We live at the other end of this large prairie. I am single. Come with me to my house and be my wife and when your child is born I will raise it as my own child. My folk will be glad to see you and for me to have you for my wife." So she went with him to his father's house.

After they had been there a considerable time, some years, and the child by the woman's first husband had grown to be quite a good-sized child, the woman, desiring to see her people, persuaded her husband to take her across the ocean to visit them. They got ready and started on their journey, but they left the little boy at home with his father's relatives.

They crossed the ocean in a sail boat with a side float to keep it upright. It was a funny boat to the Quillayutes. When they neared the village, the people saw them coming. They also noticed the odd shape of the canoe they were coming in. Everybody went down to the beach to meet them. As soon as they had landed the people gathered around them to see who they were. All were surprised to hear the woman talking the Quillayute language. When suddenly one of the Quillayute women exclaimed: "That is my sister who went to the prairie to dig ferns in the long ago. She is my sister who with me saw the dead man's head on a pole, and she wished to marry that man. And that very night he came and took her away. Yes, she is my sister."

They staid and visited and feasted a long time. Then the woman's parents wished to see their grandchild. So they persuaded the husband to go back across the ocean and bring the child over to this coast to see them. Again there was great feasting and rejoicing and "potlatching." But when the man wished to return to his home with his wife, she had decided not to leave her native village again. As a consequence, he had to go back to his home alone. That is why the Quillayutes try to marry women of their own tribe. Should they marry a woman from another tribe and she ever gets home again, it is difficult to get her to return to her husband's house.

14. THE DEER AND THE WOLF

A mother deer and a mother wolf went to the prairie to get fern roots to make into flour. Every day they would go there. And upon returning the deer would lead the way, the wolf following close behind. Moreover, when the deer climbed over a rock or log, the wolf would bite her. Also once when they went to the prairie late in the fall, the mother deer told mother wolf to pick the lice out of the hair on her head and crack them with her teeth.

Sure, the wolf bit for lice and bit hard. Every time she bit she tried to bite the deer. At last she bit her head, crushed it and killed her then and there. Then she ate her all, except a very small part of her flesh, which she saved. This she took with her to her place of habitation. There she cooked it and gave it to the deer's children. They ate it for supper, but it tasted just like their mother's milk. They then began to cry for their mother.

The wolf said to them: "Your mother told me she was going to stay up at the prairie tonight."

The wolf went again to the prairie in the morning, saying that she was going there to care for their (her and deer's) partnership work. After she had gone, the wolf and deer families of children spoke about the fun they were going to have; the two families then lived in the same long house, deer living in one end of the house and wolf in the other. The children of the deer family proposed to have a sweat-house bath for each family. So they made their preparations accordingly.

The deer children got in the sweat-house first. One of the sisters then said: "I am roasted already." The wolves then took the cover off the house, and the deer came out from their bath of purification. The wolf's family then went into the sweat-house, and the deer children covered the house up for them. But they had revenge in their hearts. They covered the house over thickly with blankets and mats and then set fire to the top. They then fled, and the big fire burned all the wolf children.

The children of the deer fled to where their uncle, the elk, lives. The largest child put the youngest child in a hollow stump, saying to it: "When the wolf passes here you halloo;" for they were sure that Mrs. Wolf would follow them, so this ruse was resorted to.

The wolf came home late that day. She passed very close to where the young deer was concealed. It hallooed to her. She came and looked around the stump, but could find nothing. She left and went looking for a track. Again the young deer hallooed. She looked again, trying to locate where the sound came from, but gave it up in despair. She could not locate the sound. So she took the track of the children of the deer and went straight away, tracking them. The object of placing the little one in the stump was to delay the wolf's following the others.

The children who had gone on came to their uncle's just a little ahead of the wolf. They had just crossed to the other side of the river into Elk's country when she came. The young elk are quick and strong. So when the wolf came to the other side of the river they picked out a spry, young elk to take a canoe across the river to get her and bring her over. The canoe he rowed had a hole in the center of its bottom. The young elk crossed to the other side and got Mrs. Wolf and started back with her. The crossing was near a big log jam. At the opportune moment the elk jumped from the boat and swam ashore. Instantly then the boat drifted into the log jam with the wolf. Under the log jam went the wolf and drowned. The children of the deer had thus "got even" with the wolf for killing their mother, for crushing her head.

15. TRICKY RAVEN AND TRICKY CROW

Once Kaiyo, the crow, lived up the river here where he had a nice little home and quite a family of girls.

One day Mrs. Crow set out for the seashore with her basket on her back, there to get some half decayed food for her little ones; anything would do, a wolf, deer, skunk, whale, sea otter, or fish.

She flew up and down the whole coast for hours, at last finding a very badly decayed fish, which she picked up and put in her basket. She then swung the basket over her back and, putting the carrying strap over her

forehead, she started home, as she sang: "Now, I have a fish. Now, I have a fish. Now, I have a fish."

She then met Mrs. Baayak, the raven, who, too, was looking for some dead animal to feed her children and herself.

Mrs. Raven saw that she had a big load. "What have you?" She asked.

"I have a fish,." replied Mrs. Crow. "I am taking it home to my little girls." Then after a moment's pause she added: "There are more fish on the beach."

As Mrs. Raven was a slight-of-hand performer, a trickster, she slipped the fish out of Mrs. Crow's basket while they were talking and put a stone in its place without the change being noticed. Mrs. Crow then flew on to her home with the load on her back, still supposing that it was the fish.

Her little girls came out to meet her, singing: "Mother, what have you? Mother, what have you?"

"I have a fish," she replied.

Her oldest child looked into the basket, then exclaimed: "Mother, mother, you have no fish! It is a stone!" Being cheated out of their supper, the little ones all began to cry.

Mrs. Crow knew at once that Mrs. Raven had tricked her. She studied a moment, then said to her little ones: "Go quickly to Raven's home. Mrs. Raven must be cooking the fish now. Go at once and get a visitor's share of it."

Mrs. Raven was just finishing cooking the fish when they arrived; the rocks had been thrown into the wooden tray containing the fish and all was boiling and done. She then took the fish and placed it in a tray and lined all the children up near it. "Shut your eyes," she then commanded, "and I will put some fish in your mouth." This was another trick.

They all shut their eyes and she then started to eat the fish herself. Mrs. Crow had secretly followed her children and at this moment she gave a loud "Caw, caw." Startled, Raven dropped the fish, and with a swift swoop, Mrs. Crow seized it. Out the door she flew, followed by her girls. She then slammed the door shut and securely fastened it so that Mrs. Raven could not get out. She and her children then ate the fish in Raven's yard, as they tauntingly called time and again: "Mrs. Raven, don't you want some fish?"

16. THE THUNDERBIRD MYTH

The thunderbird soars through the heavens and is a bird of monstrous size. Its nest is a dark hole under the glacier at the foot of the Olympic glacier field. This is an extraordinary place, and its moving about in its home produces the thunder noise there.

Once some men accidently approached this nest and became terribly scared. The bird smelled them and knew they were coming. It does not wish anyone to go near its house. So it continually causes ice to come out of the entrance to its house. So when they were there it rolled great chunks of ice down the mountain side, as it produced the "thunder noise" and shook the earth as in an earthquake. When the ice was rolled down to a level area, it was broken into a million of pieces, "rattling" as it rolled down into the valley.

This bird produces the lightning by the opening and shutting of its powerfully bright eyes as it flies swiftly through the air. It also produces the mighty winds and the "big noise" by the rapid flapping of its wings and the darting forth of the lightning snakes from the feathers of its breast as it soars through the sky in time of stormy weather.

It feeds on the whale. The capturing of a whale even by this giant bird is a hazardous undertaking. Terrible battles are fought, but the beast of the waters is finally gotten to the nest in the mountains and there devoured by the young thunderbirds.

Once thunderbird got an extraordinary large whale in its talons and started from the sea to its home with it. This whale fought terribly, and for a long time the battle seemed undecided. The powerful bird could not whip the beast in the water. Time and again it seized it in its talons and tried to fly with it to its nest in the mountains, but the powerful ocean monster fought so terribly that it would get away from thunderbird. Each time it was seized there would be a terrible battle, and the big noise caused by the flapping of the bird's wings (the thunder) shook the very mountains. The places where the battles occurred were also stripped of their timber, the trees being torn out by the roots. A curse was also brought upon these places and to this day no trees grow upon them. These places are known as Quillayute, Forks, Shuwah, Tyee, Oburg, and Beaver prairies, north of the Olympic Mountains, Long, Gibson, and sequim prairies on the Strait of Fuca side. Finally thunderbird killed the whale at Beaver prairie.

After killing the beast, the fatigued bird sat down on a limb of a tree a little above the ground to rest. Just at that moment an elk hunter came along; and, on seeing the giant bird, he secured a feather from its wing, a feather as long as a canoe paddle. He bent this feather and put it in his quiver and took it home with him. Before leaving the prairie, he also saw the body of the dead whale.

After he had shown the feather to his people, he said: "I also saw a very, very big whale on the prairie. It had been killed by thunderbird, who was resting because it had such a load. I also saw black clouds around and above the whale. When I went to examine the latter, these clouds told me they were the power of the thunderbird, were, in fact, the greater thunderbird of the heavens.

This hunter invited the people to come up the river with him and cut up the whale. He also told them that they could render out as much whale blubber as they wished and could take as much of the red meat home with them as they liked. So all the people of the beach and lower river area, three to six in a canoe, went at once to the prairie to cut up the whale.

On reaching there they found the huge whale lying dead in the lower part of what is now Beaver prairie, as the hunter had said. They then immediately commenced measuring off the parts that custom allowed each family; one family took the saddle, another the head, and so on. By evening they had it all cut up and had piled up the block-like sections of blubber all over the ground.

It was a fine sunny day when they began to cut it up; but they had barely gotten it cut up when it began to rain, snow, hail, and thunder and lightning. By nightfall the clouds overhead had also become inky black. The thunder-

bird was angry because the people had cut up his whale while he was resting as he was carrying it home. Thunderbird had been robbed of his prey, and now he was back to the scene with vengeance in his wings. Soon he caused great chunks of ice to fall. The people were scared and all who could get away fled from the place. Some hid under logs and rocks to escape the wrath of this god of the air. Nevertheless, the hail killed and mangled all who had been at the prairie. The Indians had cooked and eaten whale meat that evening and it was all right, it was good to eat; but after the storm both meat and blubber were turned to stone, as were the people also. And to this day they are lying there on Beaver prairie. In great blocks of rocks they form a (glacier-boulder) ridge from one end of the prairie to the other. One may even see the ribs of the whale's carcass and its massive head.

As the years came and went thunderbird killed more and more whales till Kwattee saw that it would be necessary to kill him to save the whale family from extinction. So he constructed a mammoth whale of very soft wood and carefully painted it to look like a whale. He then floated it over the deepest waters. As expected, thunderbird spied the decoy whale and supposing it to be a real whale, lit on it and sank its talons deep into the soft body. Instantly Kwattee turned this wooden beast to stone which held the thunderbird so fast that it could not withdraw its claws from the stone frame. Kwattee then sank the wooden whale, now stone, in the deepest depths of the ocean, and it is there still; but thunderbird's children are still living and in their searching for their long lost mother, they soar through the air in stormy times, searching out the dark places of the earth with their lightning flashes, and causing all things to tremble before their vehement "thunder noise."

17. ANOTHER WOLF-DEER MYTH:

OR, ONE SHOULD NOT LAUGH AT OTHERS

One day when Deer was sitting in the front yard of his house by the beach sharpening his canoe paddle, some wolves came along in a canoe. As they came by he began to sing a song making fun of them, as they were paddling and steering the boat very awkwardly.

The wolves became incensed at his fun-making and, landing the boat, they went to his house in a mad rage. Whereupon he stated that he had not said anything. They knew, however, that he was not telling the truth. So they grabbed him by the hair of his head, dragged him over the beach to the canoe and, putting him in it, took him down the beach to their home.

Landing, they took him into their rectangular house and placed him in a corner opposite the door, after which they prepared their evening meal. Then when it was cooked, they sat down around the great earthen bowl that contained the soup and fish and began to eat, since they were hungry, very, very hungry.

As they were eating, they counseled among themselves as to when would be the best time to kill the captive and eat him. Finally it was agreed that they would kill him the next morning.

He overheard what they had proposed to do and remonstrated, saying to them in his own defense: "No, no, do not kill me in the morning. I will be poor then. I will be all bones then."

They then agreed to kill him at noon; but he said that he was always poor in the day time, that he was fat only at night. So when they had had their supper or were eating it, they decided not to kill him that evening.

After the supper was over, all the inmates of the house, except captive Deer, stretched themselves out on their mats and went to sleep. He did not sleep. He was bent upon escaping. So when all were fast asleep and snoring, he got up and went to the opposite side of the room where he secured a knife. Then on seeing that it was "good and sharp," he went to where the chief was lying and with one blow he severed that official's head from his body. Taking the head, he fled from the place into the thick wood near by and on to the landing on the beach where he found a canoe. He got into this and pushed immediately out to sea; but, having no paddle, he merely drifted about at the mercy of the wind.

Early in the morning the wolves woke up and, finding that their chief had been killed and that Deer had escaped with his head, they tracked him from the house to the landing; but as they had no canoe they could not follow him. Things, however, were in their favor.

Deer drifted far out so sea. Then a strong east wind came up and, blowing very hard, caused the sea to become very rough. A dense fog also came on so that he could not see the shore. Moreover, he was all alone, except that he had the chief's head with him.

Out in his canoe in that murky sea he was standing up swinging the head as he hilariously danced. He was happy. Suddenly the beach loomed up before him and, lo, he was at the very landing where he had first started with the canoe. The wolves were there to receive him, too. They swam into the water and took possession of the boat. They then seized him by the hair and dragged him ashore, half drowned.

When he could get his breath, he begged them not to kill him, saying: "I am a 'skookum,' strong doctor. Give me a chance and I will make your chief alive again as he was before."

"The chief being dead and he seemingly in their power, they were willing to give him a chance. So they brought him and the chief's head back to the long house. When once inside, they put a guard on each side of the door to keep him from getting away, it being understood that he was to bring the chief back to life or forfeit his own life.

When ready he begun to sing: "Kol-le-to-ya," over and over again to work up his "tomanawis" powers, handling the head of the chief in a "tomanawis" way at the same time. Then when he had thus performed for some time, he proceeded to put the head on the headless body, placing it on so that it would be facing backwards.

At this horridness, the wolves all set up a great howl, all exclaiming in one voice: "Do not put it on that way!"

Again he took it in his hands and performed over it, saying to them: "You must give me more room. You must give me a bigger circle to dance in. I must have more room. I cannot get my 'tomanawis' to work unless I have more room to dance and perform in."

So they made a larger circle, sitting back farther toward the wall. He then performed and sang for a considerable time, after which he placed the head

on the headless body, but placed it sidewise. To this the wolves again objected vehemently.

With a swift movement he hurled the head to the ground and, as he had previously planned to do, dashed out of the house past the guards who bit at him as he passed, but instead of seizing him they bit the dust behind his fleeing feet. Every wolf in the whole neighborhood, however, was instantly after him.

He got into the thick woods and thought for a time that he would escape; but a very old wolf, who was so old that hair would not grow on his under parts, saw his track and knew it as it was very fresh. He then called the other wolves and put them on the track. They soon came upon him and quickly cornered him. Then from every side they seized him with their teeth and, though he called out for mercy, it was of no use. They tore him to pieces and that was the last of Mr. Deer.

He should not have laughed at others.

18. THE STORY OF HOW PEOPLE COURTED IN THE LONG AGO

Long ago the boys and girls employed a very peculiar method to find out when they loved each other. They cut salmon berry sprouts, as many cuts as one whole sprout would make, to cut it into small pieces of a certain designated length. If two cuts were left, that is, if the cuts were an even number, the Indians said the love was not true love. But if one cut was left, that is, the cuts were an odd number, they said the love was very true. Many old people also say that when there was only one cut left the lovers ate it up so as to put it near their hearts.

I have also heard old people say that when there was one cut of the sprout left, that is, the sprout produced an uneven number of cuts, the odd or last cut was used in a different way. The lovers split a stick part way so as to make 'a voice come out of it.' Then they put the odd cut of the sprout in the split place and left it there. This was to show that their love was firm and fast and permanent.

19. HOW THE SQUIRREL BECAME SUCH A CLIMBER

In the beginning everything on earth was an animal and all animals were human beings. At that time a certain man was walking in the woods. As he was going up a certain hill, he heard someone calling from the top of the trees. He looked up and saw a woman lodged in a tree top. She did not belong to the tribe that lived in the region and how she got into the tree top is still a mystery. She was helpless. She could not get down and was calling loudly for help. The man also gave a call for help.

Soon all kinds of animals came from all directions to where she was continually and piteously calling; but to all ordinary means of that day and time she was out of their reach, for no one of earth was then a climber.

They talked about what they should do; and it was finally agreed that someone should attempt to climb the tree. If he succeeded in reaching the woman, he was to release her and bring her down.

Beaver was the first to try to climb to her; but on account of the large size of the tree, he did not climb far, as he feared he would fall.

Skunk then tried, but failed to climb high enough in the tree. Many other

animals also tried to climb up the big trunk to where the suffering woman was lodged, but all failed.

At last Squirrel was induced to try his skill. So started to climb and kept on climbing till he reached the woman. He extricated her, put her on his back and returned to the ground with her. Since then he has been a great climber, the greatest of all animals. And he learned to climb to save a woman.

20. WHY THE RAVEN IS NOW A BIRD

In the old, old times all things of earth were human beings; and at that time Southwest Wind lived at one end of a long beach and Raven at the other end of it.

Southwest Wind knew where the best clam beds were, and dug great quantities of clams. These she would place in a pile on a rush mat, and she kept on digging till she had all she could carry home.

Once when she was out digging clams quite a distance from the clam pile, Raven came along. He was as lazy then as now and just as big a thief. He came to the pile of clams. He had a good meal there and then, without the labor of getting it.

He helped himself to everything in sight. He ate every clam.

When Southwest Wind found all her clams gone, she was mad. She took vengeance on Raven by depriving him of the privilege of getting any water in the vicinity.

From that time on when Raven would get down on his knees to get a drink out of a brook or a pool, the water would disappear. Just as he would be about to put his lips to the water, there would be nothing there to drink.

For days and days he went from place to place trying to get a drink, but got none. Then he tried a new plan. He had a blanket made of the skins of birds. This he had woven water tight. He took it to the river and filled it with water, using it as a sort of bag. He then lifted it to his mouth and started to take a drink, but the water dried before it reached his lips.

He could get nothing to satisfy his thirst. Thus he changed himself into a bird so he could fly about over the earth to get something to drink; and he has been a bird ever since, but he still has his old traits.

21. HOW THE ANT CAME TO BE

Long, long ago when people were animals and animals people, Deer and Wolf lived together in the same long house.

Wolf lived in one end of the house and Deer in the other. Mrs. Deer and Mother Wolf were on the best of terms. The young deer and the young wolves also played together and enjoyed themselves, but the wolf nature soon asserted itself with the young wolves.

One day they dug a great hole and persuaded the young deer to go down into it. Instantly, then, they covered them up so that being helpless, they could eat them.

Having covered them up, they waited for them to die; but the deer changed themselves in form and dug their way out of the pit. They so changed themselves that the wolves did not recognize them afterwards. To save their lives, they changed themselves into ants.

22. DUSKIA IS KILLED BY THE SLAVES OF THE RAINBOW

A boy went out of his father's house into the yard one evening in the long ago. He quickly returned to the presence of his father by the fire and breathlessly exclaimed: "I saw a bird on the water, a kind of duck." Then after getting his breath he added: "I want you to go and shoot that bird."

The father went at once to hunt the bird, taking his canoe and bows and arrows with him. Finally, he got close to it and shot it with an arrow, hitting it with the first shot.

It was not killed, having been shot only in the back. It had not been injured so much, and it was still able to swim. So it kept swimming off from him. It kept swimming and swimming and farther and farther it went from land, and he kept following it till he got a great way from home. At last, then, as he had become very tired, he gave up the chase and turned to the nearest land in sight, which proved to be away on the other side of the great ocean where lots of people live.

As soon as he landed he went into a house which proved to be a bird's house, a bobwhite's house—these birds were all Indians then.

As soon as he had entered the house, the quails gave him some salmon berries to eat. He then stayed there and slept, for it was night when he got there and he was very tired.

The next morning when he got ready to leave for his home, one of Mr. Bobwhite's people, a man that was made of a smooth water-polished, very hard, black rock, who was called Rock-man and could easily protect him on account of his stony nature, said: "I am going home with you; for I am afraid you will be killed by Duskia, a giantess that lives in the woods on the way."

They stopped when they came to Duskia's house, as they had decided to stay all night there. The rock-man had also agreed to sit up and watch Duskia while the other slept, pretending that he was asleep, too. And he did sleep that night.

The giantess then got up to kill them. Luckily, however, she attacked Rock-man first. She seized him by the collar bone to try to choke him to death; but her fingers were mashed and broken off.

They then immediately resumed their journey; but when they had gone only a little distance, they noticed Duskia following them to kill them.

Noticing her coming, Rock-man said to the other man: "Run swiftly, run, and I will keep this woman from harming you for a little while. Run with the greatest possible speed and when you get a little way in advance of me, halloo to Rainbow to come to our aid."

He ran and ran and ran till he got to Rainbow's house. He then hallooed to the people who dwell there to let their slaves go, for as you know many Indians live with Rainbow.

Rainbow then took its slaves off of the road work in the skies and sent them to attack Duskia. They soon passed Rock-man and went right on, brandishing war weapons as they went. They soon met the giantess, and the slaves killed her instantly, thrusting her through and through with their barbed tongues.

The man who was on his way home then stopped at Mr. Rainbow's house a long time and, while thus sojourning there, he walked about a great deal.

While thus strolling about one day he killed a deer and took it back with him to camp. Again and again he wandered away from Rainbow's home, each time going farther and farther. Then one day he went a great, a very great distance from that house, and still farther and farther he went.

He suddenly heard someone crying, then many people crying—the family and friends of the duck that he had shot in the first part of our story.

Being afraid, he fled from the place and in his flight he came to the vicinity of his own home, where he found his boy playing some distance from the residence.

He knew the boy and asked him: "Who is your father?"

The boy replied: "My father took the bow to kill a duck long ago."

The man then said to him: "I am the man that shot that duck."

The boy ran quickly and hurriedly told his mother what he had seen.

"My husband!" she exclaimed. "My husband died when he shot that duck in the long ago."

However, she went with her son to see the man; and, lo, when they got to the place there was no man there!

"O, my son," exclaimed the sorrow-stricken woman, "I now know! You have seen my dead husband! You have seen your dead father! Oh, must I part with you, too! Oh, my son, the dead you have seen! Must you die! Must you die!"

That night the boy passed to the land of Shades to wander through the worlds with his father.

23. WHY THE PEOPLE OF QUILLAYUTE ARE FEW IN NUMBERS

A long time ago our people went out whaling and killed a big whale. They then floated it with their hair-seal skin buoys and towed it home; but while towing it they did not sing and pray to Se-kah-til, the mother earth, to keep the evil spirit, Ko-kwo-til (Po-po-kahtil), from taking possession of it. So he lit on it in the night when they could not see him and poisoned the meat.

After the whale had been landed on the beach the next day, they cut it up and took it to their smoke houses, hung up the whale-saddle, and began preparations for the whale-saddle 'potlatch', as all sung and shouted and had an enjoyable time.

In the meantime everyone was preparing whale meat for supper. Then, as all were very hungry, they all ate heartily of the meat as soon as it was cooked. In fact, they were so hungry and there were so many people here in the village at that time that they ate the whale all up before the people who were away hunting elk and gathering salmon berries and sprouts could return home; but it was lucky for the latter, because the last mouthful was hardly swallowed before all who had eaten of the meat became deathly sick and in a short time they all died. The yards, streets, and houses were soon filled with dead people, only a few of our people being left.

Since that terrible day, we have not failed to sing and pray to the mother earth to keep that evil death-spirit from lighting on a whale while we are towing it ashore after it is killed.

24. THE METEOR MYTH

One evening some Indian girls who were sleeping outdoors without tent or other shelter, were looking up into the vault above at the boys up there; the Indians consider the stars as male children and men.

As they were thus star gazing one of the young ladies said: "I wish I had that man."

Another said, "I want the red one."

Another said, "I want the blue one."

Each of the stars thus chosen then darted down and seized the young lady that had chosen him and again returned on high; but after they had got to the men's home in the starry vault, the girls found out that their husbands were different from what they thought they were. The red-light one had red, inflamed, sore eyes and was always cross. The others, however, were all right and made good husbands.

25. THE MINK MYTH

Long, long ago when there was a war, Mink went along with the soldiers in a canoe, saying: "Let me stay in the bow of the boat and I will dance."

"That's all right," agreed the people in the canoe. "You stay in the bow of the boat and dance."

They all went up the river to where the rock ledge stands out into the stream some miles above Quillayute. Then as soon as they arrived at the rocks Mink jumped overboard and went below the rocks.

This desertion made those in the boat mad. Overboard and into the water they also jumped with their boat poles and tried to kill him; but, to save himself, he took the brown-backed, large Chinese slippers (mussels?) from the rocks, removed the animals from the shells, took out their intestinal canals, and wrapped them around the poles so that when they should draw them up again they would be led to believe that they had killed him and would consequently leave the place.

The ruse was a complete success. "We have killed him," they said. So they started to return to their canoes.

Mink then soon came up in the water, jumped upon the rock and sat down upon it. Then he made fun of his enemies, saying: "Yah, yah, yah, wi, cha, whet."

On hearing this fun-making, the soldiers came back and again tried to kill him with their long poles. They waited a long time, then left, thinking they had killed him, but they had not killed him; he was just fooling them as previously. This time, however, he staid beneath the surface of the water till they had gone around the bend in the river, then swam back to his home at Quillayute.

26. THE MEDICINE MYTH:

OR, THE GODS PUNISH MEDICINE MEN WHO USE THEIR "TOMANAWIS" TO KILL PEOPLE

Once, a long, long time ago a man slipped upon a medicine man while he was doctoring a sick girl and killed him with his spear there and then. He then went home.

The people then all rose as one man and went to his house to kill him,

but he stood them off. They then went to the prairie to kill his wives, who were digging fern roots to make into flour.

On seeing the armed men coming, the women loaded their baskets with roots and started for home so quietly as to make believe that they thought that everything was all right, putting up such a bold front that the men hesitated to attack them immediately. Stoically they walked towards home with their baskets till, on descending a steep hill, they left their pursuers considerably in the rear. They then dropped their baskets and escaped to their husband's house by running.

Once inside, they defended themselves with fire brands, while with bows and arrows the husband and a few of his followers dispatched each appearing individual. Then as the arrows began to run short, they turned the dogs out, and these quickly finished the work, only ten of the assailants escaping.

Thus the gods favored the individual who had killed the medicine man; because the latter had often killed people with his "tomanawis."

27. THE KAHD-DAH-DOL-KWA (DOG-CHILDREN) MYTH

A long time ago people could change themselves into animals, and animals could sometimes change themselves to people. At this time, at the village of Destruction Island, a woman gave birth to nine children, eight males and one female, who looked more like dogs than human beings. However, they were human beings merely clothed in the skins of dogs.

The people of the village believed that the gods had brought a curse upon the woman. So after one lady had abused her very much for having angered the deities, they left the place to her and moved away.

She took good care of her strange children, bathing them every morning. She also gathered many things for them to eat, and, as they liked clams very much, she would go when the tide was out at night and look for them with a torch.

Once when she returned she saw human tracks all around the fire, the tracks of her children; but she did not know it, for they had always walked as dogs do and were all lying dog-fashion around the fire at that very moment.

As soon as she had left to hunt for clams the next night, her offspring again pulled off their dog-clothes, after the manner that one would remove a union suit, and hung them up on a pole that was suspended over the fire. They then danced around and around the fire; and around and around the fire they danced, as they sang over and over again: "Osk-thlah kah-ah-dah tsee-klah-ah thl'lo kah-ah-dah" (my mother's down there; my mother's down there). And around and around the fire they danced, now human beings in appearance.

At last the mother filled her baskets with clams and started home carrying her torch. Then on seeing her coming, her children quickly put on their dog clothes, and when she arrived they were all curled up in dog-fashion around the fire, sound asleep. However, the human tracks were there. These she carefully examined and was much puzzled, but she did not say a word.

In a few nights she went clam hunting again; and as soon as she was gone from the house her offspring pulled off their dogskin suits. They then began to dance and sing as before as they watched the movements of the torch on the beach, but she was not to be fooled again. She tied the torch to a pole;

and, firmly placing it in an upright position in the sand, she came to the house without it, slipping around in the bushes and coming to it from the rear, as the children, who were thinking that she was still at the beach where the light was, were still merrily dancing and singing. Stealthily she slipped into the house from the back way and caught them performing. She got between them and their animal skins. They then quickly squatted on the floor with their heads between their knees, for they were ashamed.

"You will not fool me again," she sternly said to them. She then grabbed the clothes from the pole over the fire and burned them every one, and from that on they were human beings in appearance and nature, not acting like dogs any more.

As the years passed, these children grew stronger and stronger, for with the dawn each morning they went to the surf and bathed and rubbed themselves to develop their muscles. Then from the sinew of the deer they made bow strings to be used on a large bow which their sister had just completed. They then went to the woods and dug out a small canoe by the burning, clam-shell-scraping process. In this canoe they then crossed to the mainland and went to the mountains to hunt, and, on the return they killed an elk, which they cut up and took home, horns and all. From the horns they made harpoon points, and from the yew wood which they brought with them from the mountains they also made harpoon stalks. They also twisted spruce limbs into ropes and they made double-barbed harpoons.

With their small canoe they went to the ocean, where they killed some sea lions, which they brought home for their meat and blubber. They then killed some hair seals, which they skinned and, turning the hides wrong side out, they firmly tied up all the holes—those where the eyes, head, etc., had been. They then inflated them and prepared them for buoys. They then went to the woods on the mainland and spent a whole year making an ocean canoe of large size from a single cut of the giant cedar trees of the region. Then after it was finished they returned home with it.

They were men then. They would brave the ocean and capture the killer whale, but they must make preparation first. They must also get the will of the gods.

They spent the winter months in this preparation. At night they would go out to sea and swim the hours away, diving and swimming and pretending that they were whales coming to the surface to spout. Or they would spend the time swimming around some small rock projection, pretending that it was a whale and that they were attacking it. At morning when the sun would rise over the Olympics they would come ashore from their whale-killing play and dry themselves with a brush, being careful to keep the heavy end of the brush towards the face of the sun. Occasionally they would also vary this performance. A part of them would go to the graveyard of the island and, tying all the old skulls together that they could find, they would drag them about throughout the night till time for their morning bath and breakfast. While they would thus be doing this, others would be singing and drumming and floundering around on the floor at home in imitation of the movements of a whale in its dying struggles. In this manner the preparation was finally completed. The whale could not smell them, because of their having bathed in the ocean water and because by their ceremonies they had

obtained the will of the deities. They were then ready to hunt and kill the largest whale of the deepest ocean.

One bright morning about the time in the year after the winter has gone, when the sun goes straight across the ocean to the west, they launched their huge whaling boat while all sang and danced. Then after the mother and sister had carried all the things, whaling outfit, eatables and bedding, and placed them in the canoe, they shoved off from shore and set out in search of the king of the great waters, singing and shaking the whale rattles as they went.

They had not gone far when they saw a whale spout. To it they rowed. Near it they got; but the harpooner missed his mark and fell overboard. So this whale got away.

Again they searched the ocean, but no more whales did they see. The sun rose high and sank and, as they were miles out at sea and could not return home, they slept on the waters.

At dawn the next morning a whale spouted near the canoe, and the whale chase was at once begun, but before they got near it they had rowed about five miles. Another of the brothers was the harpooner. When they got close to it he hurled the deadly weapon with all his strength and did his work well. The harpoon held fast, and soon a long line of buoys were floating around the whale, retarding his movements. Time and again they harpooned it. At last it became motionless and apparently dead. They then rowed the canoe up close to it and one of them jumped up onto the huge body. This movement broke the stupor which had taken possession of the dying animal, and, quick as a flash, he lashed the water into foam and smashed the canoe into kindling wood; but the man on his back luckily succeeded in mastering the situation by holding onto a harpoon-buoy rope, and as soon as he possibly could, he commenced cutting the beast right and left with his dirk knife. Luckily also for the others struggling in the water among the pieces of the canoe, the animal soon died and they got on it, but what were they to do with it there? What were they to do with it and what was to become of them, as their canoe was gone!

Suddenly the fog lifted and, to their surprise, they were within five hundred and ninety yards of the very beach from which they had started. Quickly they then swam ashore. Then with their small boats and with the aid of the on-shore wind they got it near shore. They then made a tow line with the long buoy ropes and what other ropes they could get together. Then as all pulled and worked, the in-coming tide helping them, they succeeded in dragging it ashore, as they constantly sang to Sekahtil, the mother earth, to keep Kokwotil (Po-Po-Kahtil), the evil one, from alighting on the carcass and poisoning it and making it lean. At last they had it on shore. Then amid great rejoicing, they cut it up and hung the "whale-saddle" up to drip.

Just as they were hanging the "saddle" up, Crow, then a human being, flew by, and, seeing the meat, flew down and carried off a big chunk of it, which he took to his child.

Being very hungry, the young crow tried to swallow the whole piece at once, but choked to death on it. The neighbors then came to comfort wailing Crow, asking her what had killed her darling; but being ashamed to admit that she had stolen the blubber, she said it had choked on clam meat.

A Mrs. Seagull said that Crow had told what was not so; and, reaching down the child's throat, took out the chunk of blubber.

Crow then admitted that she had stolen the meat, telling them where she got it. She further stated that there was lots of meat there, meat of every kind of animal and bird, and canoe loads of whale meat; and that the children of the lone woman down there were not dogs but men.

All the people, bear, wolves, ravens, crows, eagles, sea gulls, etc., immediately went down to Destruction Island to get some of the meat; and they were given all they could carry away.

The old woman who had abused the poor woman when her children were wearing dog-skin clothes also came for meat, and the boys gave her the big tail of the whale. Then when she had swung it into her basket at her back, they shoved it, and she fell under it and was crushed to death. Thus was the mother avenged for the wrong done her in the long ago.

28. MYTH ABOUT THE BEAR AND THE RAVEN

Baayak, the raven, went to Bear's house visiting, and Bear set about to prepare him something to eat, to give him his dinner. He went outside the house and gathered some sticks to cook with. He also got some quetsetseput from near the seashore, a kind of shrub with green bark, from which an oily grease oozes out when it is placed near the fire. He then commenced to cook over the fire.

He cooked his own feet, cut them and split them so that oil would run out of them, which oil he caught in a bowl. By this means he got all the oil he needed to cook with, after which he quit roasting his feet. He then set the dinner before Baayak, giving him the oil from his feet and dried salmon to eat.

Raven ate heartily, eating all the oil and fish. Then he soon went home, inviting Bear to return the visit.

The next day Bear went to Baayak's house to dine with him, and on arriving, Baayak told him to sit down and rest himself. After a while the latter began to prepare to cook dinner, telling his wife to get the same kind of wood and the same kind of sticks that Bear had used the previous day.

Mrs. Baayak brought the wood and gave it to her husband, who immediately started to cook the meal. He cooked his feet just like Bear had the day before. For a long time he roasted them. Then he said to his wife: "Is there any oil dripping into the bowl from my feet?"

Mrs. Baayak replied: "No, no, no, nothing, not half a drop."

By this time he had begun to suffer considerably with pain: "O my!" he cried as he begun to wriggle and contort his body. "It hurts! It hurts! My feet are burning! O my! Dear me! Oh!"

His feet burned till they bent up, till the cords drew up. Yet not a drop of oil did there drop into the bowl, and Bear just laughed and made fun of him.

Baayak was very much ashamed because they had nothing to feed Bear. So the latter, laughing in mockery, went home without his dinner.

29. THE DUCK MYTH, THE ORIGIN OF THE BRIGHT-COLORED FEATHERS OF BIRDS, ETC.

The people heard some ducks on the lagoon that were different from any they had heard before. They also heard the boys shooting at them.

The birds were very, very beautifully painted in diverse colors. So lots of canoe loads of boys, who were anxious to obtain some specimens, were shooting at them, but they could not hit them, they could not shoot one.

The people (rich men) living under the water also heard the birds. At this time one of these men lived in a long house with Mr. Jay, who was almost a slave of the former, one living in one end of the house and the other in the other end. Jay also heard the birds and said to himself: "My master's daughters are going to kill those ducks. I know they are."

When night came on the girls went to bed behind the partition walls of their bedroom as usual, and while there they studied out how they could kill the beautiful birds. Then when daylight came again they took their purse-like straw baskets and went to the woods, where they secretly made bows and arrows. Late that evening they returned to their homes and went to bed without eating any supper.

Near daylight the next day they woke up again and, wrapping their heads up in turban style, they went to the lagoon with their paddles and baskets. They then went to where the boys were trying to shoot the ducks, rowing out into the lake to them.

As they were thus proceeding, one of the girls swung her hand behind her and swung her bow before her in readiness to shoot; one girl steered and rowed the boat while this one prepared the bow. She shot. 'Whiz' went the arrow, but missed its mark. Again she shot, and this time she hit the bird, but it did not die for a long time. They then rowed quickly to it and pulled it into the boat.

When they got home just at daylight they had the bird concealed in a basket. So the parents, who were still in bed, did not know and could not imagine what they had been out for. Finally one of them said: "We killed one of those ducks we heard."

At sunup the rich man told Jay to go up and open the "chimney doors." So he went upon the roof and opened them; and as soon as it was light in the house the rich man opened the basket. It then lightninged, and Jay fell down to the ground as if dead.

The people inside the house then said to him: "What are you doing there, Jay? Climb up again and open that thing, as it has closed again."

He replied: "What are you doing down there? What makes me this way? What makes me fall down?"

His master peremptorily said: "You open it."

He climbed upon the roof again; and, as soon as he had opened the "chimney windows" and his master had opened the basket, it began to lightning again, and he fell right down as formerly. Again he opened the roof, but his master did not open the basket. So it did not lightning any more. He then came down from the roof to the ground floor inside the long house.

His master then said to him: "Come over here to this end of the house. My daughter killed one of the ducks that we heard, not one of which had

ever been killed before. We will now have a potlatch. Go and call all the different creatures of every sort and tribe to the great feast."

So Jay called all the creatures of the earth to the potlatch; flees, flies, skunks, minks, pigs, dogs, coyotes, ducks, birds, snakes, sturgeon, men, and fourfooted animals.

All the invited guests came. They feasted for days and days. Then at the close of the ceremony, the rich man gave a different colored feather of the duck to each guest, because the bright-colored feathers were valuable; and each animal, bird, and what-not took the feather and wore it. That is where the bright colors originated. Sturgeon got his share of the feathers and put them on his throat, and today this feather is the beautiful plumage of birds.

30. THE CIVILIZING MYTH

Some Indians once heard that another tribe of Indians were coming to civilize them. So they made up their minds to make some weapons which they could use to drive them away. They went to the lagoon, where they could use the water to wash with and sharpen their tools. Then while making the war things they sang over and over again: "We are going to use these things on the people who are going to civilize us."

They were thus singing and grinding and sharpening clam shells for weapons, somewhat like we could whet a scythe with a scythe stone, when a civilized Indian jumped over one of them and took his whittling tools from him, as he asked him peremptorily: "What are you doing that for?" as he flashed the tools in his face.

Scared, the uncivilized Indian at once became a deer, as it fled into the woods. Then the civilized man said to it as it thus fled: "Whenever you see our people coming, you must turn your eyes over straight and look at us and then jump and run away. This is the curse I pronounce upon you for changing yourself into something else." And to this day when a deer sees any one coming, it looks at him straight and then flees away.

31. A MYTH ABOUT WHY THE BLUE JAY SCOLDS SO MUCH

The sweetheart of Kwash-kwash, the Blue Jay, died; and as he cried and bemoaned her, he took the body up the river to see if he could get a certain medicine doctor to bring her to life again, finding five doctors there when he arrived.

He asked the first doctor he came to to try the case, but he replied: "I don't wish it. I don't think I can make her alive again."

He then went to see another medicine man, who replied as had the former one. He then went to the third doctor, and he likewise did not want the case. He went to the fourth, and he told him the same thing, adding: "Possibly I could bring her back to life if she had been dead only one day, but she has been dead too long."

He then went to the fifth doctor, who asked how long she had been dead. He said for him to take her into his house, after which he started to doctor her.

He dipped his hands in water, then rubbed the dead girl's breasts, hands, and face with them. She soon came back to life again and was alive the same as anyone, finally getting well and strong.

Kwash-kwash then took her to her home to her father and mother; but when they got to the mouth of the river, her father, Ye-le-kah-ah-tilth, took her away from him and would not let him marry her.

He then became a strong medicine man and, for revenge on the father of his sweetheart, he cut out the girl's tongue, after which she soon died again.

It is this girl's tongue which Jay now uses when he scolds so much.

32. MYTH ABOUT THE BEAR MEDDLING

Once when Bear was a human being and was fishing on a little creek, he saw an old-fashioned Indian trap. In fact, every time he ever went to fish on this creek he saw it. Finally he said: "It is an Indian trick and I am going to try it. I am going into it."

Mrs. Bear was present and warningly said: "You had better not do it," but he did not listen to her.

The next morning he danced and sang over and over again: "That thing is only a small piece of a stock inside, and I'm going to pack it home."

He then went fishing again, saying: "I am going to that trap. I am going right into it." And he did. He pulled at the baited trigger, and the heavy roof fell on him and crushed him.

When it had passed time for him to come home and he did not come, Mrs. Bear became very anxious about him, and when he had not come even at a late hour that night, she came to the conclusion that he had been caught in the trap. So the next morning she sent a man to look for him, and he was found dead.

This story is told to the children to keep them from meddling.

33. RABBIT AND EAST-COLD-WIND

Kaolet, the East-Cold-Wind, and Kwade, the Goosander Duck, went up the river fishing all day together, but the latter did not catch a fish, going home without anything.

The next day, as Docas, the Rabbit, wished to go with Kwade, they started up the river together; but when they had gone only part of the way they met Kaolet, who came close to the canoe, saying to Kwade: "Why did you bring Docas with you, as you see he always keeps so close to the fire? (The Indians always have a fire in the canoe if the weather is cold.)

As he was thus talking to draw their attention, he reached out down into the canoe and took a salmon away from Kwade, who was powerless in his presence; but just as he reached down for the fish, Docas rose with his war-club and hit him a terrible death-dealing blow across his neck, severing it and breaking him in pieces, after which he scattered him to the four winds.

Kaolet was freezing everything everywhere and this was the first chance Docas had ever had to rid the world of him. So it is lucky that he used it, for the whole earth would have soon been a solid mass of ice and all living things would therefore have died. Consequently, we have Rabbit to thank for our warm times and growing seasons.

34. A MYTH ABOUT THE WINTER WREN AND THE ELK

Cho' cho', the wren, went up the river to fish for salmon in a little creek that comes into the Quillayute river about five miles from here. While he was there Elk came along and saw him—both Wren and Elk were then

human beings. He then went over to where Wren was and took his fishing harpoons away from him.

This made the latter mad and he said in his scolding fashion: "If you do that again I'll fix you. I'll go right up your nose and fix you."

Wren then went home and told his family about how mean Elk had treated him. And all, both old and young, agreed that should the insult be repeated, he should be punished.

The next day Wren went to fish at the same place and was again met by Elk.

"Cho'h, cho'h, cho'h, cho'h, go away, go away, go away, go away," screamed Wren, but the impudent beast would not go away. Instead, he seized the former's harpoons and appropriated them to his own use.

Wren then immediately proceeded to carry out his threat. He flew onto Elk's face. He flew to one of his nostrils. He entered it and went up it as he scratched and clawed.

Elk tried to sneeze him out. He then tried to blow him out; but in vain, for Wren went up and up. He then nosed the ground. He pawed the earth. He rolled. He waded the swamps and rivers; but all to no purpose, for Wren still went up and up his nose and clawed and clawed. The nose then began to bleed and he began to grow faint, finally falling to his knees on account of being so weakened because of the lose of blood. He then fell down and died.

Wren then came out of his nose and flew to his home, as he sang: "You got what you wanted, you got my harpoons, and I killed you, I killed you."

Thereupon he went home and told his people about the repetition of the insult and that he had killed Elk. So the next day the Wren people went and cut the animal up, recovered the stolen harpoons, and ate the meat. Thus did Wren get even with Elk.

35. A MYTH ABOUT THE RAVEN

One evening as Baayak, the Raven, was making a journey he came to a very inviting house, which he started to enter to stay for the night. Then, after hesitating a moment on the threshold, he said: "I am tired out; but, as the people in that building are the beings that control sleep, I do not desire to go in there." The Quillayutes believe that sleep is a being of some sort who closes the eyes of people and makes them know nothing for a while. So he sat on the porch just outside the door.

Some children were sleeping outside of this house at that time, and others had woke up and begun to play. Some of the latter then ran into the house and exclaimed: "Who is that great big nosed fellow sitting outside the door?"

The parents told the children to have the fellow come in, as he was probably their grandfather.

They brought him in and placed him in the center of the house, which had a fireplace at each end and sleeping apartments in the middle, as was the custom of the time. Then in just a little while after he had seated himself, he was fast asleep and snoring very loudly.

This woke up the people of the place, who said: "That sounds badly. Take him out."

They then considered taking him to the water and setting him adrift,

which they finally did. He then drifted away, and when he awoke he found that he was in the water where he had landed away down the coast at the mouth of the river. By hard work he finally got ashore. And since then he has never gone near the house of the sleeping people.

36. ANOTHER MYTH ABOUT THE RAVEN

Baayak, the Raven, said to a young lady: "You had better look at the salmon traps," but she was too lazy to go and examine them. However, he compelled her to go.

These traps were wide, round-mouthed box concerns which tapered down and became very narrow. They were also set with mouth against the stream; and a salmon, once getting into one, was taken by the current to the lower, narrow end in which he could not turn around. And there the swift current would hold him till he died.

On reaching one of these traps and looking to see if there was anything in it, she found that there were many fish in it. She then tried to get one out; but, instead, she fell into it herself and drowned.

After a while, as she did not return, Mrs. Baayak became anxious about her, saying to her husband: "The young lady is staying too long."

Her parents were also advised about her not returning. They then all went to look for her.

On reaching the trap they saw a floating object in it which was at first thought to be the carcass of a land otter; but it proved to be the girl's body, which they recovered amid much wailing. Then after taking out the trap, they took the corpse home as they wailed and bemoaned her.

When they got home, Mrs. Baayak upbraided her husband, saying: "You drowned the girl. You drown girls."

He sarcastically replied: "Girls should willingly do what they are told, then nothing bad will happen to them."

37. KWATTE MAKES THE THREE RACES OF MEN

Kwatte had five brothers living here in Washington, as the white man calls this part of the country. They always had a big salmon trap around, and one day the oldest brother went out fishing with it, but caught nothing. The next day the youngest went and did likewise, and so on did each of the others, till the fifth brother went. He, however, caught lots of salmon, for Kwatte, who was a great medicine man, had made the salmon to run there in great numbers.

Kwatte then took the salmon livers and made the Indians out of them; that's why the Indians are brown; they are brown just like the livers. From the white floats he then made the white people, and from the intestines he made the negro.

38. A WEST COAST INDIAN MYTH

Once in the long ago an Indian gambled till he lost all his possessions. That night when he retired, he told his people to let him alone and not disturb him in any way, as he felt very much depressed because of his loss.

That night he grieved himself into unconsciousness over his misfortune and remained so for five days. As he seemed to be dead, some men rolled him up in a blanket and left him.

While thus unconscious—dead, as the Indians term it—he went down to the regions of the dead, to the land of the departed spirits, where he found that there are two places, one for the bad and one for the good dead. He also found that the people of the good place are young and handsome looking and are happy, and the inhabitants of the other place are ungainly, miserable people with long tails.

When he arrived in the abode of the good dead, the people there all shook hands with him and were all very glad to see him. They also asked him how their friends on the earth were getting on and how soon they would join them down there. Then having asked him all the questions they wished, they told him to go away, as he had the appearance of being bad. So he left.

He then rode some distance on the back of an elk, after which he was put in a closed basket and taken a long distance. He was then taken from the basket by the attendants and placed in a barrel-drum at the top, or mouth, of a great hole in which he could see no bottom.

When he was placed in this barrel-drum he was told to shut his eyes and keep them shut till he got to the bottom, for if he should open them he would never reach the bottom, but would be dashed in pieces. He was also told that on reaching the bottom the barrel-drum would burst and he would be a free, living human being again.

As soon as he was snugly in the drum, a tight-fitting lid was placed on it, and he was started, plunging down the hole, the barrel-drum jumping and bouncing over what appeared to be steps or projections on the rock wall.

The barrel-drum at last reached the bottom and, falling hard, it burst asunder, as it had been said it would. And as he tried to rise he found that he was rolled up in his blanket so he could not move either hand or foot, and thus he awoke from his trance.

39. THE RAPE OF THE DAUGHTER OF MOTHER EARTH

Duskia, the evil one of earth and heaven, stole the daughter of Mother Earth and bound her fast in the very top of a giant cedar.

Some of the brothers of the girl were hunting in the woods at the time and heard her crying quite a distance from them, one of them saying: "What is that noise I hear? Who is that crying?"

They listened and recognized it to be the crying of their sister, knowing her voice. So they hurried home and reported the unfortunate condition she was in.

The parents then immediately summoned all peoples to their aid, promising a potlatch to all; and in one day all peoples, including snakes (the Quillayutes believe that even the snake was a person then), and all animals, bears, squirrels, birds, etc., assembled for the potlatch, where they discussed the means they would use in getting the girl down.

The next morning all the beasts and all the people assembled at the foot of the tree in which the maiden was bound. They then asked who would climb the tree first, after which there was silence for several minutes. A-kil, the Bear, then tried to climb it.

The girl, who was at the very top of the tree, then hallooed down to the people: "Do not pick those berries down there, for they are my tears." (On

reaching the ground, every tear-drop had turned into a berry, and we believe that is how the red berries became the seed of the cedar.)

When A-kil was ready to climb, he rolled up his sleeves, and the people all shouted: "Time! Go!" He then climbed up the tree, but had gone only a short distance when his hold slipped and he fell to the ground.

Another beast then tried it; then another and another. Then a funny young fellow started to climb, as he sang: "Cho-uh, cho-uh, cho-uh, cho-uh whee-al-lee-ah-lay."

The girl's parents got mad at this, for he was making fun of them. They peremptorily told him to stop his fun-making and also ordered him not to climb, but he paid no attention to them. Up he quickly climbed and "in no time" he had unloosened her.

As he sang while he climbed, his voice sounded similar to the sound produced by plunging a red hot stone into cold water, but when he had unloosened the girl he changed his voice to its natural pitch and hallooed down to the other: "How shall I bring her down? Shall I tie her up by her hair and bring her down on my back?"

Those below shouted back: "Bring her down on your back."

So this funny man brought her down on his back and restored her to her parents, afterwards marrying her.

40. THE CARPENTER-HUNTER MYTH

In the long ago two brothers lived in one house, the youngest being a hunter, the oldest a canoe carpenter. Early one morning the latter went to work at his shop in the woods, then later returned for his breakfast.

For breakfast his wife gave him a very little seal meat and nothing else. Another day he went to his work the same way, and on returning she gave him the same food as before, and as little of it. He then asked her: "Is that all the meat my brother gave us?"

She curtly answered: "Yes, sir."

He then became angered because his brother gave them so small a piece of meat, for he knew that he killed many seal every day. He got madder and madder. He then went into the woods and made a hair seal out of wood, finishing it the next morning. He then snugly inclosed it in a seal skin and placed it in a conspicuous, natural position among the rocks where he knew his brother would be sure to find it.

Early the next morning, as the Carpenter Brother was setting out for the woods, the Hunter Brother saw the decoy seal lying on the rocks and told his partner in his canoe work to go and kill it.

The latter then put everything, his spear, buoys, etc., in his canoe and set out across the little lagoon to where it was lying, watching it closely as he slipped very easily upon it. Then when he got quite close to it, he harpooned it; and though it sounded like wood, no sooner had he struck it than it dove into the water and took in the whole buoy line that was attached to the harpoon, and with its powerful swimming it began to tow the canoe toward the big ocean at such a rapid speed that he could not get close enough to it to harpoon it again. The weather then changed, and when a fog arose he

began to feel sorry, because he saw that he and his hunter partner were going to be lost.

After a while the seal came to the surface, the first time they had got close to it since it was harpooned, and when they rowed up to it there was no doubt but it was dead. They then started to put it into the canoe and found out that it was wood.

They then tried to find out who had made the decoy, "who had done that thing to them," and it was finally decided that it was the hunter's brother who had made it and had caused all the mischief. Then said the partner to the brother: "Did you give your brother his portion of the seal meat each time you returned from a hunting trip?"

He replied, lyingly: "I gave him half of the seal meat, half of it."

Suddenly the weather then quickly changed and the sky became clear. The partner then saw the land close at hand and said: "There is land. A bluff is very close yonder."

The other replied: "We are not far from home. This is our country."

For a considerable time they discussed which way they should go, as they paddled up and down the shore. Then after a while they saw a canoe coming toward them with one inmate in it.

As they were approaching each other the lone man in the strange canoe would occasionally disappear from view for a short interval. Consequently they watched him with increasing interest, becoming certain that he was diving right straight down into the water.

When they became sure that the man was swimming under the water they became afraid and hid themselves. Then from their concealment they watched his movements more closely, to see if they could tell what he was doing.

Nearer and nearer he approached them. Right in front of them he passed. Again and again he dove beneath the surface, and—came up with a halibut, which he put in his boat, for he was diving for fish.

Being hungry, the navigator said to his partner: "When that man dives again, let us go to the boat and get one of his fish." After a moment's reflection he then added: "We will have time to get it before he comes to the surface again."

The fisherman dove again and the others pulled their canoe down to the salt water, for they had hauled it up on land when they became scared. To the lone fisherman's boat they rowed, stole a fish and escaped with it, then hid themselves on the beach before he returned to the surface again.

When he came to the surface and got into his boat, he knew that some one had been there. Moreover, his "tomanawis" caused him to point his flat palm toward the place where they had gone. He then took his hand back before his face and smelled it, knowing exactly where they were by the smell.

He was a small man, nevertheless he was not afraid. He immediately landed on the shore where they had left the sea, and from there he was able to track them by the scent, walking directly to where they were hiding behind a log. He then caught the one with his left hand, the other with his right, and carried them to his canoe, finally taking them to his home.

When he got in front of his village he hallooed to his chief to come out and get the captives. And he came and got them. He then took them to his house and begun to prepare food for them, as they warmed themselves.

When they were somewhat warmed they became observant of the things around them. They also noticed that the chief was cooking the old-fashioned way by throwing heated rocks into wooden trays containing the vegetables.

When the food was cooked and set before them, they would not eat it, for they saw that it was a dish that Indians are forbidden to eat; they were afraid that if they ate it they would die.

They had money and with it they bought their freedom, after which they bought the chief's house. They then began to wander up and down the village to find something to eat; and, in an obscure place, they found some fish heads, which they cooked outside the town limits. They then sat down and had a meal on these fish heads, the first time they had had anything to eat for a long time. In this way the tribe where they were also found out that they ate fish. So from that on the chief furnished them fish to eat, and they always had plenty to eat.

Then one day when they were eating their dinner in the years that came and went, they heard a great noise, which proved to be sea-gulls and moon-ducks flying about the village as they loudly sang.

This singing and flapping of wings scared all the people of the village where they were, and they hid themselves under their beds in their houses and in the hollowed out, massive cedar door posts, which were often six feet through. The birds, who were truly world destroyers, then came into the houses, but finding nothing, they flew back to the sea.

These destroying birds came again two days later, and this time there was a battle in which the hunters came to the rescue of the tribe. They killed them with clubs, sticks, and stones. As a result, the birds were defeated and more of them were killed than any man can count. Then after the battle they picked up the best ducks, and with these they prepared a feast for all the people.

The next day the destroying birds came again; and as they were seen approaching, the chief called the captives to him and ordered them to kill all the birds if they could. And they killed them nearly all that day.

They again picked up the good ducks and cooked them all at one time, cooking them the old-fashioned way; they cut them open and put hot stones inside them, then they covered them with ashes.

The chief then called all his people into one big house so he could pay the hunters (captives) for saving his tribe. Then when they had all met together and he had paid them, they consulted as to how they would send them home; and, as an outcome of this conference, the chief ordered his people to get all kinds of animals and bring them to his house.

Among the animals they brought was Killer Whale, to whom the chief said: "You take the strangers home on your back."

Killer Whale replied: "I go too swift for those men and I also dive too deep for them."

The chief then asked Tsus-sub-bes, the Sperm Whale, to take them. "All right," he replied, "I'll take them. Cut a hole in my back and put them in it."

The chief then asked Tsus-sub-bes if he could not carry some beads also, as he would make the men a present of them for killing the destroying birds.

To this request Tsus-sub-bes gave consent and allowed the bags of beads to be placed beside the men in the hole in his back. He then set out for the

open sea with the understanding that he was to take them home at night so that no one would see them, being also ordered to leave them on the shore opposite the hunter's house.

When they landed that night they unloaded as much of their goods as they could, but they had hardly got half of them ashore when daylight came, and Whale, of necessity, had to go back.

That day the "lost" hunter invited all his tribe to his house, and everyone but his brother whom he had cheated out of his share of the meat came, all being glad that he had come back. He then sent a man to get this brother and bring him to his house, but he still refused to come. He then sent another man for him, and this time he came.

Upon entering the house he acted as though he was ashamed of himself, whereupon the hunter said to him: "Canoe Carpenter, stand up, stand up there, as I am going to do something to you."

"I am going to do something to you," he retorted. "I will change you into a white calcite rock, and for years and years the people will call you rock."

And so he made him turn into stone there and then for the wrong he did him in not giving him his portion of the seal meat in that long ago.

41. ANOTHER MYTH ABOUT THE RAVEN

Baayak, the Raven, said to his wife: "I have invited all the creatures of the earth to our hall and I am going to pretend to give a great potlatch, though I am actually only going to give a few things away at low tide. Then I will kill them all by guile, and we will have a great feast ourselves."

The table for the killer whale, sperm whale, seal lion and bear was placed on the beach at the water's edge so that they could get fresh clams and sea-eggs and other eatables from the sea at will. The tables for the others were then set in the hall itself.

So at low tide everybody, Bear, Whale, Wolf, Deer, and so on, came to the heralded feast. The feast was set and all helped themselves to the eatables set before them. All ate heartily and all had an enjoyable time.

After the eating was completed, a series of dances were introduced. There were whale dances, deer dances, elk dances, seal lion dances, seal dances, and many other kinds of dances; and everybody danced.

Then after the dances were completed wrestling matches were introduced. And Ta-ta-kwe-al, the strongest man in the woods, challenged Ka-la-tob, the second strongest man, to wrestle with him.

Time and again they wrestled with head holds, Kalatob being the loser, though it was nearly a tie. All the people present then told them to stop, as they were so nearly even, but all acknowledged that Tatakweal, who was recognized as the strongest man in all the world, for he could hit a tree with his fist and knock it down, was a little the best.

All the people then said to Bear: "You had better try your luck." The friends of Whale also said: "Whale, you wrestle with Bear."

Whale and Bear then stood up to wrestle, using the head hold, as they held each other by the head. Over the beach they contested, seeming for a while to be about an even match. Then Whale threw Bear heavily to the ground; but he was instantly up again and ready for the fray. Whale threw him down again, which much angered him. Up he then sprang and a battle royal fol-

lowed. And Bear scratched Whale, cutting great gashes in his throat, which you can see on any sperm whale's throat today, making him look like he had on a mammoth life preserver.

Being ashamed of Bear's luck, Deer then challenged Winter-Whale, but was worsted in the first round. He then got mad and gashed him with his feet the same as Bear had done his whale; that is the reason that the winter whale has two ridges down his breast now. This bout closed the wrestling.

After the wrestling match, Baayak heated a great number of rocks, pretending that he was cooking something the old-fashioned way. Then when they were a white heat, he went all around the feast-space carrying one of them in a looped stick, as he sang and told the people to shut their eyes and open their mouths as he had something good to give them.

Sea Lion was the first one to open his mouth wide. Baayak then quickly threw a hot stone into the wide mouth and down the distended throat.

A terrible howling, bellowing followed, and the visitors all got scared and rushed out of the house énmasse.

Baayak then quickly turned to his wife and said in commanding tones: "Bring the spear over here. I cannot trick them, so I will spear them."

In haste she brought the spear to him, and he made a thrust at the big fat sea lion with it, exclaiming: "I hit it." To his wife he then said: "Come quick and help me hold the lion so he won't get away. Come quick."

She hesitatingly asked: "Did you hit it? Are you sure you hit it?"

He replied: "I did. I sure hit it. Here! Here, hold this line."

At that instant Seal Lion escaped from the house. Baayak had missed his mark and had hit the door-post instead.

Then Mrs. Baayak said to Baayak: "You have utterly failed. You have captured nothing. You have given all our things away, and now we have nothing for ourselves. You are always planning something and never accomplish anything."

Antigenic Studies on the Genus Pasteurella

GLENN C. BOND and CORA M. DOWNS, University of Kansas, Lawrence, Kan.

INTRODUCTION

With the discovery by Hueppe, in 1886, of a bipolar staining rod which caused hemorrhagic septicemia in certain lower animals, there was established a genus of bacteria called by several different names, in its gradual enlargement to the present genus Pasteurella.

In this group have been placed those organisms meeting two requirements, namely, those organisms showing bipolar staining and causing a hemorrhagic condition in the host. Many such organisms have been described and the investigators have resorted to the method of naming them according to the host from which they have been isolated. This method of naming these organisms has caused a great deal of confusion and uncertainty as to classification within the genus, since organisms from the same species of host may exhibit marked differences in biochemical and serological reactions.

As a result of this confusion some investigators regard these organisms as constituting a single species and others regard them as a genus. Bergey, in his "Manual of Determinative Bacteriology," lists Pasteurella as a genus composed of six species: those causing hemorrhagic septicemia in certain animals, as *P. avicida, P. boviseptica, P. suiseptica* and *P. cuniculicida;* those pathogenic for man and rodents as *P. tularense* and *P. pestis.*

PURPOSE OF THIS WORK

The purpose of this work was, if possible: (1) to find a basis whereby hemorrhagic septicemia organisms, isolated from different hosts, could be distinguished by their serological reactions; (2) to determine if these organisms may be divided into subgroups within the genus; and (3) to determine especially the serological relationship of *P. pestis* and *P. tularense* to the rest of the Pasteurella group and to each other.

REVIEW OF LITERATURE

Most of the reported work has been done with the animal strains of Pasteurella, and the attempts at classification have been on the basis of biochemical reaction and various serological reactions.

Biochemically no satisfactory method of classification has been determined. Jones (1) suggests a method of grouping based on cultural characteristics. This applied only to strains of bovisepticus. Attempts by other investigators to use this method have not been satisfactory.

Serologically several attempts have been made to find a suitable method of classification. The results of these investigations show that at least three types of conclusions were formed as follows:

Lal (2) and Hughes (3), from serological findings, conclude that the organisms studied by them were host specific.

Jones (1), Roderick (4), Tanaka (5), Cornelius (6) and Newsom and Cross (7), from their results of various serological reactions, conclude that within the genus Pasteurella there are groups of organisms which may be differentiated

by biochemical and serological reactions, but this grouping does not correspond to host origin.

Lal (2) quotes Matsuda as concluding that the various members of the group are distinct species capable of specific identification.

Conflicting as these results are, they sufficiently emphasize the fact that a very close relationship exists between these organisms, and to determine their distinctive characteristics, if they do exist, delicate and reliable serological tests must be employed.

Very little work has been done on the relationship of *P. pestis* and *P. tularense* to the rest of the Pasteurella group and to each other. De Smidt (8) studied the serological affinities of *P. pestis* for other organisms of the Pasteurella group. Using cultures of *P. ovisepticus, P. suisepticus, P. bovisepticus* and *P. murisepticus* against *P. pestis* immune serum by the agglutination reaction, he found no cross-agglutination, and thus concluded that the members of the Pasteurella group have no serological relationship to *P. pestis*. No reported work was found in regard to the antigenic relationship of *P. tularense* to other members of Pasteurella.

CULTURES

The cultures used in this work consisted of four strains of *P. avisepticus,* two strains of *P. suisepticus,* eight strains of *P. bovisepticus,* eight strains of *P. ovisepticus,* two strains of *P. pestis,* two strains of *P. bubalisepticus,* one strain of *P. equisepticus,* three strains isolated from the buffalo, and six strains of *P. tularense.*

The names of the above indicate their source of isolation. All grew on plain agar except *P. tularense,* and it was grown on dextrose cystine blood agar.

PRELIMINARY WORK

A preliminary study of the strains to be used included a brief morphological and biochemical study.

Nothing differential could be determined from the morphology of the organisms or of the type of colony formation.

Biochemically, with the use of sixteen different carbohydrate broth media, litmus milk, gelatin, H_2S production, indol production, nitrate reduction and bile solubility, no definite relationship as to host origin could be established. By selections of certain carbohydrates fermented by all strains of one host type, a classification was established which could be used for these strains studied, but with so many variations it would not be a very practical method.

SEROLOGICAL STUDIES

As has been stated, there is much disagreement as to the antigenic relationship of the animal strains of this genus. The various methods used by a single investigator check very well, but in the results of different investigators a close correlation is not found, thus indicating that antigenic properties of organisms isolated from the same host type vary with the organisms.

In this work it seemed best to use the agglutination, the complement fixation and the absorption-agglutination reactions to determine serological relationship.

AGGLUTINATION REACTIONS

Antisera. The antisera used in this work was secured by repeated injections of selected strains of organisms into normal, healthy rabbits, previously examined for the presence of normal agglutinins for each strain of organisms used. Much difficulty was encountered in the preparation of these antisera, due to the weak antigenic properties of these organisms. This difficulty has been also previously reported by D'Aunoy (9), Tanaka (5) and Roderick (4).

Injection of formalin-killed cultures, followed in some cases by injection of living cultures, were made until a satisfactory titer was obtained. At no time was a high-titered antiserum obtained for these organisms, but by keeping the antiserum frozen the titer remained very constant throughout the work.

Six immune sera were prepared. It was desired to secure an immune serum for each host type, but in spite of the variety of procedures used a serum of satisfactory titer could not be obtained for *P. avisepticus*, *P. bovisepticus* and *P. suisepticus*. Immune sera were prepared for *P. bubalisepticus*, 13; *P. pestis*, 16; *P. equisepticus*, 15; buffalo, 21; *P. ovisepticus*, 19; and *P. tularense* A.T., 29.

Antigen. The antigen used for agglutination tests was a formalized saline suspension of organisms and, in a few cases, fresh living saline suspensions. These were used where the other suspensions showed spontaneous agglutination.

Equal volumes of antigen and antisera in varying dilutions were used in the agglutination tests. The results given in the following chart are not quantitative, but only show whether or not agglutination was obtained in any dilution.

Antigen.		Tularense antiserum.	Pestis antiserum.	Ovisepticus antiserum.	Equisepticus antiserum.	Bubalisepticus antiserum.	Buffalo antiserum.
Avisepticus	7	—	—	+	+	+	+
	8	—	—	+	+	+	+
	10	—	—	+	+	+	+
	41	—	—	+	+	+	+
Bubalisepticus	12	—	—	+	+	+	+
	13	—	—	+	+	+	+
Equisepticus	15	—	—	—	+	—	+
Buffalo	20	—	—	+	+	+	+
	21	—	—	+	+	+	+
	25	—	—	—	—	—	—
Pestis	16	—	+	—	—	—	—
	17	—	+	—	—	—	—
Suisepticus	22	—	—	—	—	—	—
	38	—	—	—	—	—	—
Bovisepticus	6	—	—	+	—	+	+
	18	—	—	—	—	+	—
	23	—	—	—	—	—	—
	33	—	—	—	+	+	—
	47	—	—	—	—	+	—
	48	—	—	—	—	—	—
Ovisepticus	19	—	—	+	+	+	+
	24	—	—	+	+	+	+
	27	—	—	—	—	+	—
	29	—	—	+	+	+	—
	30	—	—	+	+	+	+
	32	—	—	—	—	—	—
	43	—	—	+	+	—	+
	36	—	—	—	+	+	—
Tularense A. T.	29	+	—	—	—	—	—

From the above table it is evident that there is an antigenic similarity between many of the animal strains of Pasteurella used. This antigenic relationship has little correlation with the host grouping, since so much irregularity existed between the strains of a single host group. Neither do the results obtained offer a basis of dividing this genus into groups based on serological differences as has been done by Jones and others. No serological relationship between *P. pestis* and other Pasteurella organisms is evident. *P. tularense* shows no antigenic similarity to any of the other strains of Pasteurella.

COMPLEMENT FIXATION TESTS

Complement fixation, using a modification of the Kolmer-Wasserman technic, and icebox fixation with the above-mentioned antisera and special defatted titrated antigens, gave results very comparable to those secured by the agglutination reaction. In a few cases fixation was secured where agglutination was not found, and also the reverse condition was found. The results bear out those found in the preceding agglutination tests.

ABSORPTION AGGLUTINATION TESTS

The technic employed here was to mix equal volumes of antiserum and antigen, let stand overnight in the icebox to allow absorption to take place, centrifuging the suspension and using the supernatant fluid in agglutination tests with the homologous antigen. Suitable controls of antiserum absorbed by the homologous antigen were used in all tests.

The results here gave an idea of the quantitative relationship between those strains showing cross-reactions by the agglutination and complement-fixation tests. The results obtained check very closely with those of the agglutination tests.

One thing of interest found here was that strain 15 (equisepticus) and strain 21 (buffalo) are identical, in that complete absorption of antibody content took place. This checked with a + + + + complement fixation and + + + + agglutination.

These three preceding serological tests enable one to draw the following conclusions: (1) There is an antigenic similarity between many of the animal strains of Pasteurella, but this has little correlation to host grouping; (2) the results offer no basis for dividing the genus into groups based on serological differences; (3) no serological relationship is evident between *P. pestis* and other Pasteurella organisms; (4) *P. tularense* shows no antigenic similarity to any of the other strains of Pasteurella.

RELATIONSHIP OF PASTEURELLA AND BRUCELLA

The antigenic relationship of *Pasteurella tularense* and *Brucella abortus* has been recognized for some time. Since this work was a comparative study of the Pasteurella group, it was thought necessary to determine if *P. tularense* was the only Pasteurella organism antigenically related to the Brucella group, or if it was a genus relationship. The former relationship was believed to be true, since no antigenic relationship had been previously determined between *tularense* and the other strains of Pasteurella.

Each culture of Pasteurella used in the previous work was set up against

abortus antiserum by the agglutination test. Likewise, each prepared Pasteurella antiserum was titrated against a suspension of *B. abortus*.

The results of the above show that five strains of *P. tularense* were agglutinated by *abortus* antiserum at a 1:20 serum dilution. *P. pestis* was not agglutinated. None of the animal strains was agglutinated. The homologous antigen was agglutinated to 1:640 serum dilution.

Tularense antiserum agglutinated five strains of *tularense* to titer limit 1:1,280. *Abortus* antigen was agglutinated to a 1:20 dilution.

P. pestis antiserum did not agglutinate *B. abortus* antigen, nor did any of the antisera prepared from the animal strains of Pasteurella.

DISCUSSION

The present status of the members of this group of organisms in systematic classification is certainly questionable.

Should these be considered as a homogeneous group of organisms exhibiting some differences, a heterogeneous group with cross relationship of some species and not others, or a genus consisting of several poorly defined and irregular groups? Should it be considered as a group made up of closely related animal strains and entirely unrelated human strains, as implied in Bergey's classification, or should these human strains be considered in a different genus entirely?

Culturally it seems impossible to determine any method by which these host types can be identified.

Serologically a classification of animal strains based on host origin is impossible because of the marked cross-relationship exhibited by the strains studied.

The identification of the human strains serologically is possible, since no serological reaction was evident between *P. pestis* and *P. tularense* or between these organisms and the animal strains.

Dividing this genus into groups is also impossible. The reported work of other investigators in regard to this method of classification has never given a method which would include all strains used. Cornelius failed to place nine out of twenty-six. Jones, working with strains of *bovisepticus,* failed to place one. Newsom and Cross failed to place four strains of *ovisepticus* using Jones' plan of classification.

These results certainly show that the genus Pasteurella is composed of a heterogeneous group of organisms, a few identical, a few entirely unlike, and the majority showing serological interrelationship, but not being identical.

The advisability of including *P. pestis* and *P. tularense* in the Pasteurella group depends entirely on the selected basis of classification. If this genus is to include gram-negative bipolar staining rods causing hemorrhagic septicemia in animals and plague in man, then they may be classed as Pasteurella. Culturally they are not homogeneous enough to be unmistakably related. Serologically it might be more advisable to class *P. tularense* with the Brucella group of organisms because of its very evident serological relationship. This place of classification of *P. tularense* has been adopted by Topley and Wilson and others. Serologically *P. pestis* would not be a member of the Pasteurella group, but until more serological evidence is found it can just as well be left in the Pasteurella group.

Until a uniform basis of classification has been agreed upon, the animal strains of this genus must be considered as a heterogeneous group of organisms, and the human strains as two distinct species. The current basis of naming the organisms leads to much confusion, so that a common name for all animal strains might be more desirable.

CONCLUSIONS AND SUMMARY

From the results and observations in this work the following conclusions may be stated:

1. No suitable method of classification based on cultural characteristics could be determined.
2. The weak antigenic properties of these organisms as previously reported was verified.
3. Much cross-serological relationship was evident between the animal strains of Pasteurella used.
4. No correlation between host origin and antigenic structure was apparent.
5. No satisfactory method of grouping these organisms into subgroups could be devised.
6. *P. tularense* has no serological relationship to other members of the genus.
7. *P. pestis* has no serological relationship to other members of the genus.
8. A definite serological relationship exists between *P. tularense* and *B. abortus* which is not found with other members of Pasteurella.

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Notable Trees of Kansas: I

FRANK U. G. AGRELIUS and HELEN I. SCHAEFER, Kansas State Teachers College, Emporia, Kan.

The present article is the first of a series. The authors are undertaking this work upon the suggestion of Prof. William Chase Stevens, of the University of Kansas. It is hoped that in honoring these outstanding specimens of the plant kingdom, men may really be doing credit to themselves. Full credit is acknowledged to the many people who have assisted in any way in the preparation of these papers.

THE WESTMORELAND CEDARS

(Figures 1 and 2)

On the farm of Will Robson, about two miles northeast of Westmoreland, are two red cedar patriarchs, the older of which is believed to be not less than 250 years old. They are growing on the northern slope of some white clay bluffs which rise from the little stream of Rock creek. Possibly these are the oldest living trees within the state. Scars of early prairie fires are easily distinguishable on the trunks, while the limbs are scattered and show the effects of Kansas winds.

Given memories and speech, these old citizens could relate many a stirring tale of the events that have passed in succession before them—tales of the merciless elements and savage beasts and still more savage men. Likely many of these memories would better be memories only.

In the vocational agriculture building in Westmoreland there is a section of a cedar from the same locality as the two above. It shows over 400 annual rings. This tree, when death claimed it, had probably lived a life paralleling that of our nation.

THE LINCOLN ELM

(Figure 5)

On the evening of December 2, 1859, Abraham Lincoln delivered a pre-election speech while standing before a window in a small Methodist church in Atchison. The church was filled to overflowing, and outside was a larger group around a small elm tree, listening to Mr. Lincoln through the opened window. Although December, the weather permitted this outdoor gathering to hear, in part, an address of two hours and twenty minutes delivered by the great emancipator. This speech is said to have been the most elaborate one he ever gave in Kansas.

Ten years later the church was torn down. The elm, now more than eighty years old, and a beautiful specimen nearly nine feet in circumference, is still standing and receives careful attention from the proud citizens. The Daughters of the American Revolution erected a granite boulder upon which is placed a bronze tablet with an inscription commemorating the occasion. This is placed about one-half block away and on the opposite side of the street from the elm.

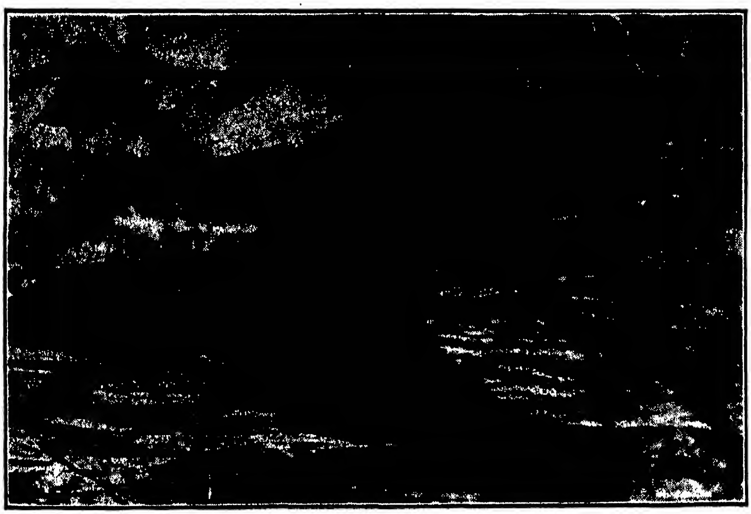

FIG. 1. Portion of a trunk of a red cedar nea Westmoreland. (*By Pickett; courtesy State Board o Agriculture.*)

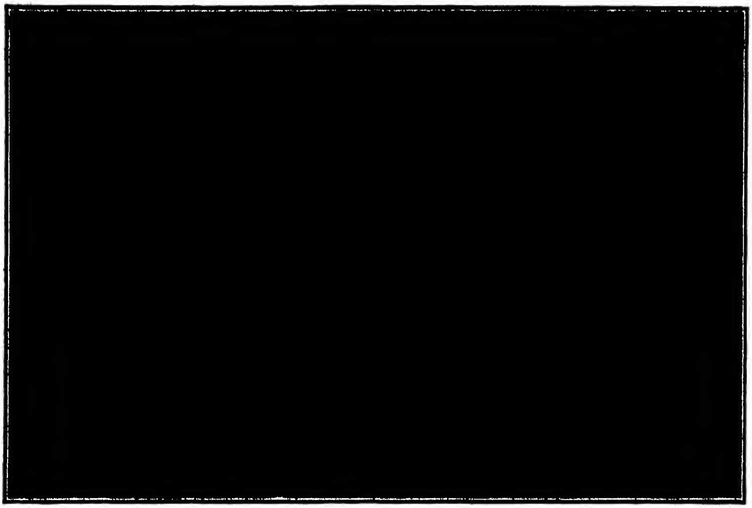

FIG. 2. The same red cedar. (*By Gates; courtesy State Board of Agriculture.*)

FIG. 3. Trunk of Council Oak, in Council Grove, March 11, 1935.
FIG. 4. Council Oak in Council Grove.
FIG. 5. Lincoln Elm in Atchison.
FIG. 6. Logs from the Gladfelter cottonwood from near Emporia. Tree felled January 4, 1921.

THE SIGNAL OAK

People were not the only actors in Kansas during the troublous times preceding the Civil War. The Signal Oak, on "Big Hill," in Baldwin, had its share in giving material assistance to the free-staters. When border ruffians were making their forays, a lantern would be hung in this tree to warn the settlers of their danger.

When this tree was cut down, two gavels were made from its wood. One of them was used in opening the Republican convention of 1928, when Mr. Hoover was nominated. A history of the gavel was read at the same time. This gavel was immediately stolen by a University of Illinois student and was never recovered. The other gavel was used in the Quayle conference of the Methodist Church in Kansas City in 1928. The Signal Oak stood near Doctor Quayle's land in Baldwin. This gavel is now in the possession of Baker University.

THE COUNCIL OAK

(Figures 3 and 4)

Travelers on the Santa Fe Trail were often subject to serious raids by the Indians. In an attempt to stop this practice, a council was held between commissioners of the United States government and the Indians, and a treaty was signed under an oak tree beside the trail. The signing of this treaty was on August 10, 1825. One of the commissioners, George C. Sibley, named the tree "The Council Oak" and had one of his men, Big John Walker, carve "Council Grove" upon it. This is the origin of the present name of the city. This tree had a tablet on it previously, but there was none on it March 11, 1935. The tree is alive and apparently will live much longer if permitted to do so.

THE STATEHOUSE COTTONWOOD

(Figure 7)

This tree is still standing, although it does not appear to be in a condition promising much longer life. It is a large one. Its spread of top is given as about 100 feet. Because of ample room for growth, it has taken on a wide-spreading form, being much wider than tall. Its origin is not known to us. Some suggest that it grew from seed. Others think that it may have come from some guy stakes used in building the east wing of the capitol in 1868.

Presidents Harrison, McKinley and Taft made speeches under it. It is probably our best-known Kansas cottonwood.

THE EMPORIA COTTONWOOD

Napoleon, when standing before a great pyramid, said, "Thirty centuries look down upon you." Pyramids are made of stone and other nonliving substances—inactive, passive, unresponsive—and they may be expected to endure through the ages. But to stand in the presence of a living monument—a giant creation that has endured all the myriad experiences of many scores of years; that has fought countless battles with all sorts of foes; that has been active and responsive—an actor on the stage of life and yet has never "called for the curtain"—is to feel something far more inspiring than a great pyramid can create in a beholder. This feeling is heightened when the object is a

tree. The marvels of growth alone are more than enough to stagger the mind of a thoughtful observer. A tree is rooted to one spot. From this place it must secure all the materials of earth, air and water needful for its existence. It may not run away for anything, or from anything.

A real giant, such as we have mentioned, was an old cottonwood tree that stood on the east bank of the Neosho river east of Emporia. It was a noted tree. John Hinshaw, of Emporia, is authority for the statement that its circumference, long before its death, was more than twenty-nine feet. The near highway was much traveled and many people stopped to observe it, and some took of its thick bark as mementoes. It was heralded in the newspapers as the largest tree in Kansas, which it probably was. Many people picnicked under its ample shelter. Some built fires beneath it and later others placed the fires against its base. A hole, extending upward some distance through its trunk, served as a chimney for these fires and this probably hastened its undoing—a grievous crime against such a noble old citizen as this. It was cut down about 1914. Thus ended the existence of this veteran at a ripe old age.

ANOTHER EMPORIA GIANT

This tree, known as the "Gladfelter cottonwood," grew on the farm of W. A. Gladfelter, about one mile north of the Emporia townsite. It stood on the south bank of the Neosho river. It was a beautiful tree, with a long, straight, shapely trunk. These facts, with its great size, marked it for cutting. It was felled January 4, 1921. The task of hauling its four ten-foot logs to a sawmill was a difficult one. Four days were required to saw it into lumber. It yielded 5,586 board feet of lumber in the form of two-by-sixes. Several excellent photographs of this tree exist and succeeding generations of men may profit by its existence after its material has passed away.

FIG. 7. The Statehouse Cottonwood. (*Courtesy State Board of Agriculture.*)

Kansas Botanical Notes, 1934*

F. C. GATES, Kansas State College, Manhattan, Kan.

The winter of 1933-'34 was mild and very dry. The deficiency in precipitation is now 22 inches in two years. Some cold weather occurred in February, and there were dust storms in March and April. The elms and maples that flowered early were nipped by severe freezes, and seeds were developed in very small quantities. Many trees died during this winter. This was particularly noticeable in bottom-land woods, where cottonwoods and boxelders were the chief sufferers.

The slippery elm, *Ulmus fulva,* developed fruits late without the flowers having come out from the bud scales. The flowers were ready to come out at the time of a severe freeze in February, but never opened. Most of such buds had but a single fruit developing and projecting a little over half way out of the bud scales. The largest number found for any bud was three. The scales remained through the fruiting, but fell off along with the fruit as a whole bud.

Two plants of garden lettuce lived completely through the winter.

The spring of 1934 showed great irregularity. A few plants bloomed particularly early (*Trifolium repens*), but most plants were late in blossoming.

On a plant of *Oxalis violacea,* C. W. Sabrosky found 7 petals.

Some plants of *Bromis inermis* exhibiting striped leaves, in which the white streak extended into the panicle, were found by C. O. Johnston a year ago. He collected seeds from the various spikelets in and out of the white streak and planted these. He found that irrespective of whether the seeds were collected in a part of the spikelet in the white streak or in the normal green part, not one of the 144 seedlings which developed showed striped leaves.

A study of the number of trees that were killed by the extreme drought of the summer in Manhattan has been prepared by Mrs. Elsa Horn Stiles and Prof. L. E. Melchers for publication in another part of this volume.

The extraordinarily hot and dry season of 1934 seriously affected plants in north central Kansas. Herbs of numerous species were killed. Autumn field trips which usually net from 70 to 80 species gave only 25 to 30. Many woody plants were dead, notably a large number of willows in prairie draws. Excessive pubescence was noted, especially in *Iva xanthifolia.* Smaller fruits than normal were present, especially in Quercus and Juglans, although the number of fruits was not greatly reduced in all cases. Shrubby plants and many forbs were without fruit in the fall. In no year within the past twenty have so few grass flowers been found in the fall. The weed population in general was the smallest known; on the other hand, the conditions favored excessive abundance of a few plants, especially the annual sunflowers, *Helianthus annuus* and *H. petiolaris.*

Several trees put out new leafy branches after the rains in September. These frequently, especially in *Acer saccharinum,* developed no separation layer whatsoever. After the killing frosts the dried leaves remained on the trees all winter.

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* Contribution No. 350, Department of Botany and Plant Pathology, Kansas State College.

Kansas Tradescantias were reidentified by R. E. Woodson, Jr., Kansas Xanthiums by E. E. Sheriff, Kansas Grindelias by J. A. Steyermark, and Vernonias by H. A. Gleason.

Collections during the year were very scanty, but did include a small group of Cowley county plants from C. E. Burt, a group of Cheyenne county plants from Mrs. John M. Steller, a few Saline county plants from John Hancin, and miscellaneous others. The work on preparation of the state flora was carried along during the year and included the checking of more than half of the Kansas State College herbarium, the herbarium at the University of Kansas, and a collection of Sedgwick county plants in the Sacred Heart Junior College collected by Sister M. Aquinas.

C. S. E. P. work was available and permitted the mounting and inserting of between three and four thousand plants in the herbarium.

Assistance on points of distribution and other features of Kansas flora was given to workers on the shelterbelt project, particularly to Prof. J. M. Aikman of Iowa State College, and C. A. Scott of Manhattan.

Information on the distribution in Kansas of *Acorus calamus* was furnished to Murray F. Buell, University of Minnesota, Minneapolis, Minn.

Kansas Mycological Notes, 1934*

C. L. LEFEBVRE, Kansas State College, and C. O. JOHNSTON, United States Department of Agriculture, Manhattan, Kan.

Despite the fact that the mycological work of Dr. Elam Bartholomew was known over the world, other Kansas biologists have made far too few contributions to that branch of botany. With his passing, it is all the more important that the information pertaining to this subject be recorded in some available form. In order to stimulate interest in a study of the fungi, we are recording our observations on noteworthy species, including those occurrences of fungous diseases that are apparently becoming more definitely established in this state. We hope that with these notes as a starting point, others interested in the subject will, in the future, submit them to us or present such observations themselves at meetings of this kind. These observations are not of such nature as to warrant a detailed publication, but we believe they are of sufficient interest, taken as a group, to deserve recording for future reference.

The cumulative effect of three extremely dry years on the distribution and prevalence of diseases of cereal crops was clearly evident in 1934. Infections of the rusts of small grains and corn were, with few exceptions, extremely light, and limited in distribution to scattered localities where local rains, during the growing season, favored crop growth. One notable exception was a very heavy infection of leaf rust on wheat in several counties in south central Kansas, where abundant rains fell in May and June. In the extreme eastern part of the state, a light to moderate leaf-rust infection occurred on wheat. West of the 98th meridian there was almost no rust of any kind on wheat. Even in the eastern part of the state stem rust of wheat and oats and crown rust of oats were difficult to find in most fields in 1934. Mildew (*Erysiphe graminis*) and leaf blotch (*Septoria tritici*) were abundant in many wheat fields as far west as Salina and Wichita in the early spring, but these diseases disappeared during the dry weather of April.

Covered smut of wheat was abundant in some localities in 1934, but the total amount for the state was unquestionably lower than usual because of the failure of large acreages in the western half of the state caused by extreme drought. On the other hand, judging by the number of smutted samples received at Manhattan, there apparently was an increase in the amount of bunt in the eastern half of the state.

Loose smut of wheat seems steadily increasing in Kansas, although the amount of infection in most fields is still small. Further increases in loose smut can be expected from the heavy infections in the Mediterranean type wheats of northern Texas and southern Oklahoma and the severe infections in certain varieties of winter wheat of the Turkey type grown in Nebraska.

Stewart's disease, caused by *Aplanobacter stewarti,* seems to be increasingly prevalent and severe on sweet corn in Kansas, especially on the variety Golden Bantam. In May and June, 1934, the disease also was noted in several instances on seedlings of field corn.

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* Contribution No. 347 from the Botany Department, Kansas Agricultural Experiment Station, Manhattan, Kan.

Covered smut (*Ustilago hordei*) on barley seems to be increasing in the state, due primarily to the increase in the acreage of winter barley during the past two years. Heavy infections of covered smut were noted on winter barley in south central Kansas in the spring of 1934, especially in Sumner and Sedgwick counties. Some samples of threshed seed from the latter county received by the Kansas Agricultural Experiment Station had such a heavy spore load that the grain was nearly black.

Darluca filum for several years has been a serious parasite on pure line cultures of *Puccinia triticina* used in wheat leaf-rust studies in the greenhouse at Manhattan. It has not been destructive to ordinary rust cultures kept in the open on the greenhouse benches, but attacks pure line cultures that have been grown under lantern globes with thin cotton covers. The fungous mycelium develops within the open uredia and the rust spores disappear within a few days, often causing loss of the entire cultures.

An interesting fungus has been observed on ornamental oak trees on the Kansas State College campus in the last two years. Three pin oaks, *Quercus palustris* Muench, and one willow-leaf oak, *Quercus phellos* L., each tree a fine specimen 30 to 40 years old, have died in that period. In each case the tree died in the late summer or early fall, but was allowed to stand several weeks before it was cut down. While still standing, the bark became loose and began dropping off the bole in large sections. The thinner bark on small limbs and branches also was ruptured in numerous places. The entire surface of the wood beneath the bark was covered with a heavy layer of brownish fungous spores. The inner surface of the bark also was covered with a layer of spores. This condition extended from the base to the top of the tree and spread even to small branches. Samples were sent to Dr. L. E. Wehmeyer of the University of Michigan, and the fungus was identified as *Diatrype stigma* (Hoffm.) de Not., ordinarily considered merely as a saprophyte. No evidence is at hand to prove that it was parasitic in this case, but the fact that it appeared in fruiting form on standing trees soon after death in dry years like 1933 and 1934 suggests that such might be the case. A similar disease caused by a fungus that produces a hard jet-black stromatic layer underneath the bark of dying soft maples, *Acer saccharinum* L., was found affecting maples on the college campus at Manhattan. The fungus causing this trouble has been identified as *Nummularia clypeus* (Schw.) Cke.

A canker of Golden willow, *Salix vitellina* L., has killed many trees of that ornamental species on the Kansas State College campus in recent years. The causal organism has been identified as *Phyllosticta apicalis*. Brownish black cankers develop on twigs and small limbs and rapidly increase in size until girdling occurs, thus causing the death of branches.

A case was observed in 1934 in which leaves of a hawthorn tree, *Crataegus crus-galli* L., was heavily infected with *Gymnosporangium globosum*, but in which very few aecia developed. This tree stands near a group of red cedars that were heavily infected with cedar rust, and the hawthorn leaves are always heavily infected, and nearly all infections usually bear aecia. In 1934, however, although there was an abundance of pycnia, only about 10 percent of the infections bore aecia. An examination of the pycnial infections showed that there was little or no exudate of nectar. It seems likely that the extremely dry air and high temperatures of the summer of 1934 prevented the

accumulation of nectar and probably also decreased the germination of pycniospores. Such conditions naturally would reduce the number of aecial infections.

Although it has been very dry during the past year (1934), several specimens of flooring, thoroughly decayed by *Poria incrassata*, have been received from various parts of the state. These specimens evidently were from buildings in which the flooring was more or less permanently moist, either from being in contact with moist soil or from being exposed to seepage of moisture from the outside where closely bordering shrubbery had been heavily watered.

The following list includes the more interesting fungi recently collected. Some of these (indicated by asterisk) have not previously been recorded for Kansas.

Aecidium yuccae Arth. on *Yucca glauca* Nutt.
**Badhamia panicea* (Fr.) Rost. growing over Coleus and Acalypha sp.
Darluca filum (Biv.) Cast. on *Puccinia triticina* Eriks.
**Dictydium cancellatum* (Batsch) Macbr. on decaying wood.
**Ganoderma sessile* Murrill on decaying stump.
**Helminthosporium leucostylum* Drechs. on *Eleusine indica* Gaertn.
**Nummularia clypeus* (Schw.) Cke. on *Acer saccharinum* L.
**Phyllosticta apicalis* Davis on *Salix vitellina* L.
**Poria incrassata* (B. and C.) Burt on decaying oak flooring.
**Sclerotium delphinii* Welch on *Delphinium ajacis* L.
**Sporotrichum poae* Pk. on *Dianthus caryophyllus* L.
Steganosporium pyriforme (Hoffm.) Cda. on *Acer platanoides* L.
**Ustilago lorentziana* Thüm. on *Hordeum gussonianum* Parl.
Ustilago striaeformis (*Westd.*) Niessl. on *Hystrix hystrix* Millsp.

The Occurrence of *Sclerotium delphinii* Welch in Kansas

D. J. OBEE, University of Kansas, Lawrence, Kan.

In the summer of 1933 there was observed in a rock garden in Lawrence a fungus parasitizing a patch of *Ajuga reptans* L. The following summer the fungus had spread to various parts of the garden, and in addition to *Ajuga reptans*, was parasitizing *Lysimachia nummularia* L. and *Sedum acre* L. Dr. A. J. Mix made isolations from *Ajuga* on August 9, 1934, and obtained an organism that appeared to be *Sclerotium delphinii* Welch.[1]

Growing on potato dextrose agar this fungus exhibited those characteristics that distinguish it from *Sclerotium rolfsii* Sacc., a closely related species, as listed by Stevens.[2] These characteristics include ropy mycelium and concave sclerotia varying widely in size from 0.8 to 5.18 mm. in diameter. These sclerotia frequently have pits or depressions on their surface, and are of a buff to tawny to Hay's brown color. A comparison of the fungus from *Ajuga* made with authentic cultures of *Sclerotium rolfsii* Sacc. obtained from H. H. Whetzel, L. D. Leach, G. F. Weber, and C. W. Edgerton, and cultures of *Sclerotium delphinii* Welch from H. H. Whetzel, also proved without doubt that it was *Sclerotium delphinii* Welch. This is the first time this species has been found in this vicinity, and as far as the literature reveals, in Kansas.

1. Welch, D. S. A Sclerotial Disease of the Cultivated Delphinium. Phytopath. 14:31. 1924.

2. Stevens, F. L. A Comparative Study of *Sclerotium rolfsii* and *Sclerotium delphinii*. Mycologia 23:204-222. 1931.

The Drought of 1934 and Its Effect on Trees in Kansas[1]

ELSA HORN STILES,[2] Manhattan, Kan., and LEO E. MELCHERS,[3] Kansas Agricultural Experiment Station.

PART I

METEOROLOGICAL CONDITIONS, 1934

The record-breaking temperatures, together with a pronounced shortage of moisture, made the year 1934 one of the most disastrous years ever known in Kansas for crops and vegetation in general. Several significant records are worthy of mention. According to the Weather Bureau at Topeka, Kan., the average temperature for the year, 58.5° F., was the highest since the establishment of the state-wide weather record service in 1887. July was the hottest month ever known to occur in Kansas, while the average temperature of the summer established a 48-year record. Extremely high temperatures began about the middle of June and continued with increasing intensity with scarcely a break until after the middle of August. Temperatures of 105° to 111° were common throughout July and the first two weeks in August. The maximum at Manhattan was 115°, while 113° occurred on several occasions. On July 13 a reading of 119° was reported at Lincoln, Kan., which exceeded by 3° any other authentic high-temperature record ever reported in the state. Complete records for temperature and precipitation for March to September at Manhattan, Kan., are shown in table 1.

The year 1934 began with a mild, dry January, with frequent dust storms. Snows in February offered some relief, but serious dust storms resulted from dry, windy weather throughout March and April. This was followed by the warmest May on record. June was warm and dry. It was the fifth successive year with a deficiency in precipitation, each year having a less amount of moisture than the preceding. The average for 1934 for the state as a whole was 20.02 inches, which is 6.77 inches less than normal, and the least on record except in 1910 and 1917.

The meteorological conditions of 1934, coupled with greatly reduced subsoil moisture in 1932 and 1933, prepared the way for one of the severest tests on the survival of vegetation, not only on crops in general, but also on long-established vegetation, as native trees and shrubs, both evergreen and deciduous.

This unusual situation afforded an opportunity to make a definite record of the effect of the heat and drought on trees in Manhattan, Kan. The writers were interested in learning what effect the drought and excessive heat produced on the various species of trees which have long been established in their present locations. The same environmental conditions probably would not be encountered in other cities in Kansas; therefore, the first part

1. Contribution No. 349, Department of Botany.

2. Formerly an instructor in the Department of Botany, Kansas State College.

3. The authors gratefully acknowledge the assistance given by the following nurseries: Bernardine Nursery, Parsons, Kan.; Caldwell Nurseries, Caldwell, Kan.; Griesa Nurseries, Lawrence, Kan.; Kansas Evergreen Nurseries, Manhattan, Kan.; Kansas State Forest Nurseries, Hays, Kan.; Leavenworth Nurseries, Leavenworth, Kan.; Prairie Gardens Nursery, McPherson, Kan.; Weaver Nurseries, Wichita, Kan.; Wilder Nursery, Wilder, Kan.; and Willis Nursery, Ottawa, Kan.

TABLE 1.—Temperature and precipitation records, Manhattan, Kan., 1934

Date.	March.			April.			May.			June.			July.			August.		
	Max.	Min.	Pre-cip.	Max.	Min.	Pre-cip.	Max.	Min.	Pre-cip.	Max.	Min.	Pre-cip.	Max.	Min.	Pre-cip.	Max.	Min.	Pre-cip.
1	52	31		67	41	0.33	84	61		103	75	T	105	67		110	83	T
2	62	38	0.01	80	42		80	60		97	63		103	61		107	73	
3	59	40		78	66		70	58	T	95	70		106	77		108	64	
4	62	33		68	51	.06	70	55	0.49	91	70		111	82		110	81	
5	52	34	T	63	51		80	52	.42	104	68	T	109	70		112	82	
6	53	26		61	46	T	89	54		100	76		84	69	0.61	113	83	
7	44	26	T	72	37		93	57		100	74		89	52		113	85	
8	51	16		80	43		93	59		102	76		100	59		113	84	
9	42	22		87	53		92	69		101	66	T	103	81		113	83	
10	44	8		90	46		80	53	.71	89	59	0.53	109	80		114	84	
11	55	28		77	54		83	48		93	64	.15	107	82		110	77	0.09
12	80	41		58	39		87	65		94	54		111	73		111	72	.05
13	66	42		66	30		80	49	2 23	97	62		112	83		106	75	
14	54	18		79	33		68	49	.32	95	68	.35	115	75		106	79	
15	68	35		63	44	.10	78	45		88	68	.50	115	74		109	73	.14
16	81	33		68	33		80	47		89	65	.12	111	83		92	73	.03
17	73	18	.01	70	49		85	53		85	63	.02	111	82		103	72	
18	43	10		82	.35	T	87	61		90	56		111	80		113	80	
19	75	26		69	38		89	63		97	63		113	87		93	71	T
20	86	39		67	31		90	64		104	77		112	80		84	58	.47
21	70	39		75	29		90	68		95	61		109	82		91	61	.02
22	54	33		77	50		82	55		100	65	.22	107	81		91	63	
23	36	27		74	53		87	48		102	68		107	80		93	67	
24	41	22	.01	65	39		76	57	T	106	80		110	71		81	52	
25	55	17		71	34		77	39		104	76		112	74		86	56	
26	48	37		75	55	.03	81	49		107	77		96	77	.08	97	56	
27	53	13		66	39		84	46		105	76		97	69	.16	93	63	
28	69	30		77	39		90	54		105	77		101	62		90	60	
29	76	49		85	52		102	58		109	79		109	68		93	55	
30	59	29	.28	86	57	T	103	65		99	75		100	59		100	66	
31	57	29					103	71					109	71		105	74	
Totals			0.31			0.52			4.17			1.89			0.85			0.80

of the paper and data presented apply specifically to the environment and soil conditions existing in the city limits of Manhattan. The second part deals with a study of the reaction of trees in nurseries in several counties in Kansas to the drought.

It became evident in early July that many beautiful trees in the city would die unless rains came soon. Much of Manhattan's beauty lies in her sturdy trees. Citizens were advised and urged to build earthen dikes around their trees and to water thoroughly. This was done by many property owners and unquestionably hundreds of trees were saved by frequent applications of water.

A SURVEY OF THE TREES OF MANHATTAN, KANSAS

Three sources of information were utilized in this study: (1) The data on precipitation and temperatures were tabulated to see what bearing these have on the vitality of the trees in Manhattan, Kan. (2) A survey was made of a definite area in Manhattan to determine the extent of drought injury to the various species of trees which have long been established in their present locations. (3) Information was obtained on the drought injury to evergreens and deciduous trees in various nurseries in several counties representing three distinct sections of Kansas.

The first of these has been discussed above. The second consisted of a detailed study of an area bounded by Poyntz avenue on the south, Sunset avenue on the west, Fairview-Fairchild-Fremont streets on the north, and the old Blue river channel on the east. From the geography and zoning of the city, it seemed that such an area could well be a representative section through the heart of the city, four blocks wide for its whole length from the old Blue river bed on the east to the inclining hills at Sunset Cemetery on the west. This included natural areas at both extremities; bordered the business section, Poyntz avenue, on the south; and included old and new, poorer and more well-to-do residential sections.

Each city block served as a unit within this belt, and every tree was observed or examined in the yard and alley as well as in the parking. The species was recorded (in some cases the genus only); its physical condition noted by numbers, as No. 1, dead; No. 2, nearly dead; No. 3, injured; No. 4, apparently uninjured; and No. 5, watered or not watered. (Table 2.) As the survey progressed, this last notation seemed imperative, since the watering of trees certainly was a biotic factor altering the effects of the drought. A circle of grass, a trench, or moisture around the tree while the soil adjacent was dry and grassless or weedless were accepted as evidence of watering. This survey was made during the months of August and September when the injury was strikingly apparent.

The approximate age or size of tree was not recorded. All trees from a well-established sapling stage to old trees were counted, whether they were planted or volunteer. Also, all woody plants having the distinct tree form were counted, whether the species is ordinarily classified as a tree or not. For example, individuals of smooth sumac having a tree form, *i. e.*, a single stem some distance from the ground, were included. Those species of a shrubby form were not considered.

The city park of 12 blocks (45 acres) in the center of the surveyed belt was omitted, because most of the dead trees were removed so promptly that no accurate counts could be made. The belt actually surveyed in 50 units covered an area of 253 acres and is 15.6 percent of the city's total area of about 1,627 acres.

Several errors may enter into the accuracy of the figures obtained in these studies. One factor may tend to raise the figures of dead trees which actually are the result of drought and heat, while other factors may have a tendency to lower the figures on the actual loss of trees. The severe injury resulting from the redbud leaf folder insect for the past seasons is undoubtedly partially responsible for the death of some of the redbud trees herein reported. The canker worm did an immense amount of damage to the elm trees, so that probably some of the dead elms may be as much the result of insect injury as from the drought. However, it is known that in other years when an abundance of soil moisture was present, canker worm-injury has not killed the trees attacked, but in 1934 the situation was different. Also, it was observed that canker-worm-infested trees which were sufficiently watered did not die in 1934. Again, if it had not been for the extensive watering on the part of some property owners, more trees of various species than the figures show would probably have died. The age of a tree or the depth of its root system might affect its reaction. There is also the error of including those trees which die in such an area simply due to having reached the limit of average life of the species under city conditions.

In spite of these possible factors of error, of which the writers are fully aware, the data obtained show some facts which are significant and which indicate that some species withstood the drought better than others.

RESULTS AND CONCLUSIONS

1. Tabulations show a total of 8,116 trees examined for drought injury. Of these 539, or 6.64 percent, were dead; 1,040, or 12.81 percent, were nearly dead; 2,515, or 30.99 percent, were definitely injured; 4,022, or 49.59 percent, were apparently uninjured by the drought; 2,308, or 28.43 percent, were watered.

Approximately 20 percent of the trees were dead or dying and an additional 30 percent of the trees were injured, mostly because of drought. About half of all the trees were apparently uninjured.

2. The number of trees within a city block ranged from a minimum of 46, representing 5 species in a schoolyard and 47 representing 12 species in a less favorable business block, to a maximum of 235, representing 33 species in a newer, more well-to-do residence block. In the schoolyard, where 46 trees stood (mostly in the parking), 42 were watered by the city, but 20 were dead or nearly dead and only 13 apparently uninjured. In the block having a total of 235 trees, although 93 were watered, 54 were dead or dying, and 143 were apparently uninjured, showing that while watering could not save all the trees it did save many.

3. For the sake of convenience, and to note whether the trees in one part of the city suffered more than another, the area was divided crosswise into 13 sections like a 13-rung ladder.

It is interesting to note that the 1st and 13th sections, at both extremities, each had 24 percent of their trees dead or dying, and 47 percent and 48 percent, respectively, uninjured. They both contained natural or wild areas. In the first section 1.5 percent, and in the thirteenth 6.6 percent of the trees were watered. These sections must represent the nearest approach to the effect of the drought under natural conditions. Contrasted with these, section 4, between Fifth and Sixth streets, had 36 percent dead and dying, and 26 percent, the lowest percentage, apparently uninjured, with 6.7 percent of the trees watered. On the other hand, section 10, just west of the city park, between Fourteenth and Fifteenth streets, jogging into Sixteenth street between Leavenworth and Fairchild streets, had 8 percent, the lowest percentage, dead and dying, and 66 percent apparently uninjured. (Sections 11 and 12 have 69 percent and 71 percent apparently uninjured.) Perhaps the low percentage dead and the high percentage sound trees in section 10 can be attributed to the fact that 63 percent of the trees were watered, the highest percentage watered in any of the surveyed areas.

In summarizing this point, one might conclude that the drought and heat killed about 25 percent of the trees and injured another 25 percent under nearly natural conditions. Under less favorable city conditions, such as an older section of poorer residents, the drought killed more than 33 percent, leaving about 25 percent of the trees uninjured. Under more favorable city conditions, such as a newer section of more well-to-do residents, the drought killed less than 10 percent of the trees and injured about 25 percent. This small loss in this section is no doubt due largely to watering of over half the trees.

4. The American or white elm far outnumbers any other species planted in Manhattan. Of the 8,116 trees of various species examined, 2,622, or 32.3 percent, were white elms. They are among the most beautiful trees in the city. Nearly 600, or 22.5 percent, of this species were dead or nearly dead, the greatest calamity which has ever struck Manhattan's natural beauty. Over 1,000, or 41.4 percent, were apparently still sound. The records reveal that over 700, or 28 percent, had been watered.

The slippery or red elm, although represented by only 61 specimens, averaging about two per block, fared better. Six trees, or 10 percent, were nearly dead; 37, or 60 percent, were still sound, although only 20 percent had been watered.

The Chinese elm was represented by 220 trees. Of these 25, or 11 percent, were dead or dying; 144, or 64 percent, were still sound. It would seem they fared better than the other elms; however, the relative age of the Chinese elms and the American elms is a factor of importance which has not been evaluated in the Manhattan survey. Also 109 Chinese elm trees, or 50 percent, were watered. Hence it would seem they were better cared for. Where the two species were grown in the same nursery and were about the same age, the Chinese elm showed less injury. This is borne out by the data in tables 2 and 3.

5. The complete survey shows 75 species listed, although several are indicated by genus only, such as apple, cherry, plum, ash, and catalpa; or only one or several species of a genus were singled out, while all others were grouped under the genus, as in Populus or Picea.

According to number of individuals, the white elm, as stated above, heads the list with 2,622 trees, or 32 percent of the total. The nearest approach in number to the elm is the red cedar, with only 629, or about 8 percent of the total. Arborvitae, soft maple, hackberry, cherry and black walnut follow in the three-hundred group; Chinese elm in the two hundreds. In the one-hundred group are mulberry, boxelder, apple, smooth sumac, ash, catalpa, pear, peach, Scotch pine, pin oak, and cottonwood. Between 100 and 50, follow the redbud, plum, Lombardy poplar, tree-of-heaven, slippery elm, Russian olive, Austrian pine, and black locust.

6. It would seem that distribution may be a better index of the importance of a species than the number of individuals. Following is a list of the species in the order of the number of blocks or units out of the 50 into which the surveyed area was divided and in which each occurred: White elm, in 50 or all of the blocks; black walnut, in 49; hackberry, 48; Chinese elm and red cedar, 47; mulberry, soft maple, arborvitae, cherry, boxelder, pear, 46-40. In the 39 to 30 group are peach, ash, catalpa, apple, redbud; 29 to 21, plum, tree-of-heaven, pin oak, slippery elm, Lombardy poplar, Scotch pine; 18 to 10, Russian olive, persimmon, honey locust, cottonwood, Norway maple, basswood, Austrian pine, black locust, hard maple, willow, sumac, Kentucky coffee tree, spruces (other than Colorado blue), red oak, sycamore; 9 to 3, cultivated junipers, poplars (other than species listed elsewhere), Colorado blue spruce, white pine, weeping willow, bur oak, dogwood, wahoo, hawthorn, staghorn sumac, birch, chestnut oak, hickory, golden willow, ironwood, western yellow or ponderosa pine, Prunus (other than cherry or plum). Those which occurred in only 2 blocks were prickly ash, buckthorn, thornapple, osage orange, tulip tree, black sugar maple, horse chestnut, jack pine, viburnum, mountain ash, and white poplar. Those found only once were white oak, 6 unidentified oaks, shingle oak, pagoda-tree, apricot, devil's-walking-stick, quince, Cornelian-cherry, and pitch pine.

7. A third index of the importance of a species, as it exists in the minds or hearts of the citizens, might be revealed by a study of the number of trees of the various species which were watered. Again, taking those occurring in numbers of 50 or more, we find that less than 10 percent of the black locust, mulberry, and boxelder trees were watered; the cottonwood and smooth sumac, 10 percent; those between 15 and 20 percent, arborvitae, hackberry, ash, Scotch pine, slippery elm; from 22 to 30 percent, red cedar, tree-of-heaven, black walnut, peach, pear, Austrian pine, American elm, plum; from 35 to 38 percent, Lombardy poplar, apple, catalpa; from 44 to 50 percent, redbud, cherry, Chinese elm. The soft maples with 61 percent and the pin oaks with 80 percent lead the list of favorites if watering is taken as an index. The percentage of watering would be higher in the rarer species of fewer individuals. For example, all six of the unidentified oaks on a single premise were watered, though only 2 survived.

8. However interesting the results concerning the importance of the various trees in this survey, it would be of greater interest to determine, if possible, the value of the species based on drought resistance. This is difficult because the very indices of importance in sections 3, 5, 6, and 7 above, enter in as elements of error; namely, condition, number, distribution, and watering. It would seem that those species with the highest percentage of trees

surviving and with the lowest percentage of trees watered are the most drought resistant. Taking the watering into consideration, however, would introduce inaccuracies in an evaluation. Watering was not done under controlled conditions. Some of it was unnecessary; much of it was ineffective. If the factor of watering is disregarded, the species may be arranged on the basis of their percentage of survival as shown in table 2.

The trees listed in columns 3 and 4, which are designated "injured" and "uninjured," have survival value. Table 2 shows 16 species of which there were more than 100 individuals distributed throughout one half or more of the units in the area surveyed. Eleven other species or genera are included because of their distribution and popularity. Forty-five additional species occurred in the survey, but these are not included in the table because of their rather small numbers. They are, however, listed in section 6.

The percentage of survival of red cedar and arborvitae is based on a corrected estimate as given in table 2. Many of these trees were planted so closely that it was difficult to distinguish the individuals. The rows, therefore, were designated as "R" in the field notes and counted as 1 in the original tabulations. In table 2 each "R" is conservatively estimated to represent 10 instead of 1, and the percentage of survival is based on this correction.

9. The entire city of Manhattan, on the basis of the area surveyed, has about 52,000 trees. There were 1,570 dead, or essentially dead, trees in the 253 acres which were surveyed. On the basis of 6.2 dead trees per acre in the surveyed area, Manhattan had about 10,087 dead trees in the entire city area of 1,627 acres in the fall of 1934. It is assumed that the number of dead or nearly dead trees in the unsurveyed area is in the same proportion as in the surveyed area.

TABLE 2.—The percentage of survival, condition and distribution of some species of trees in the Manhattan, Kan., survey, 1934.

Name of Tree.	Percentage of survival (a).	1 Number of trees dead.	2 Number of trees dying.	3 Number of trees injured.	4 Number of trees apparently uninjured.	Total number of trees.	Distribution. Occurrence in number of blocks out of 50.	Number of trees watered.
Red cedar	95.9(b)	14	14	67	634	729	47	137
Tree-of-heaven	95.7	0	3	9	58	70	28	16
Arborvitae (Oriental)	94.2(b)	3	25	115	478	652	44	61
Pear	94.0	2	6	38	86	132	40	37
Hackberry	92.6	12	15	148	191	366	48	66
Russian olive	90.5	1	4	13	35	53	18	12
Slippery elm	90.1	0	6	18	37	61	24	12
Chinese elm	88.7	6	19	51	144	220	47	109
Smooth sumac	88.6	25	10	51	66	152	16	11
Catalpa	87.0	0	18	63	58	139	35	51
Ash	85.9	2	18	70	52	142	36	28
Pin oak	85.7	6	10	37	59	112	26	89
Mulberry	85.3	3	23	37	114	177	46	14
Peach	83.3	2	20	40	70	132	39	34
Plum	83.0	2	13	30	43	88	29	26
Cottonwood	82.1	5	14	44	43	106	17	11
Lombardy poplar	79.9	11	7	21	49	88	23	31
Redbud	78.7	5	15	48	25	93	30	41

Name of Tree.	Percentage of survival (a).	1 Number of trees dead.	2 Number of trees dying.	3 Number of trees injured.	4 Number of trees apparently uninjured.	Total number of trees.	Distribution. Occurrence in number of blocks out of 50.	Number of trees watered.
Apple	77.9	22	13	36	87	158	34	58
White elm	77.5	168	421	947	1,086	2,622	50	727
Soft maple	76.9	21	68	143	154	386	45	235
Austrian pine	76.8	3	13	9	44	69	14	17
Boxelder	75.9	7	34	68	61	170	43	14
Black walnut	71.6	29	68	90	155	342	49	88
Scotch pine	64.3	23	22	35	46	126	21	23
Cherry	59.0(c)	101	53	92	112	358	44	161
Willow	43.5	13	13	4	16	46	20	8

(a) Percentages obtained by using the number of trees in columns 3 and 4.
(b) Percentages are based on the corrected number of trees as discussed in text.
(c) This low percentage may be chiefly due to the cherry leaf-spot disease which reduced the vitality of the trees.

PART II

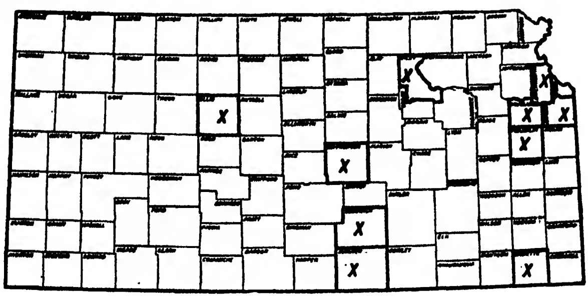
THE EFFECT OF THE DROUGHT OF 1934 ON NURSERY TREES IN KANSAS

In connection with the study on the effect of drought on the trees in Manhattan, Kan., it seemed desirable to learn what effect the state-wide drought had on trees in various nurseries. The data are confined to young forest trees which were well established and for the most part consisted of stock three years old or older; in some cases the trees were eight and ten years of age. Shrubs or shrub-like trees are not listed. An examination of the nursery stock under the severe conditions of 1934 gave an opportunity to compare the reaction of some of the species of trees in the nursery with older trees of the same species which were growing within the city limits of Manhattan. However, a large number of species are represented in the nurseries which are not grown in Manhattan.

Ten nurseries in Kansas furnished the data herein presented. For convenience, the reaction of nursery stock to the drought is given in this paper by (1) the county in which the nursery is located and (2) by section of the state. In the latter classification, an arbitrary grouping is made to cover (*a*) central[4], (*b*) east central, and (*c*) eastern Kansas.

The discussion considers the degree of injury occurring on deciduous trees and on evergreens. The degree of injury is expressed by the terms, "no injury," "very slight," "slight," "severe," and "very severe" injury. "Very slight" and "slight" mean that trees were not killed, but that there was some injury noticeable to the leaves, twigs, or trunk because of the heat and lack of soil moisture. "Severe" injury means that some of the trees were killed, and "very severe" means that many were killed. Wherever it is desirable, the degree of injury is supplemented by an additional descriptive footnote.

The common names of the trees used are those given in Standardized Plant Names, in as far as possible. In a number of instances the authors are not certain of the species or the common varietal names used by the nurseryman, and these are questioned. The difficulty of a common name being used for different horticultural varieties is a situation that is commonly met with in a study of this kind. Numerous question marks will, therefore, be noted in the list.



A map of Kansas (Fig. 1) shows the counties in which the nurseries occur that furnished the information. Beginning with Ellis county and working eastward, a tabulated list, by county, is given of the nursery stock, with notes on drought injury (table 3).

4. Only one nursery in Ellis county is represented.

TABLE 3.—The degree of drought injury to trees in nurseries in several counties in Kansas in 1934

Species.	Counties in Kansas.									
	Ellis.	Riley.	McPherson.	Sedgwick.	Sumner.	Leavenworth.	Douglas.	Johnson.	Franklin.	Labette.
DECIDUOUS										
Acer ginnala (Amur maple)									2 (a, b)	
Acer negundo (Boxelder)	4								0	
Acer nigrum (Black maple)						2				
Acer platanoides (Norway maple)								2	0	
Acer platanoides schwedleri (Schwedler maple)								2	0	
Acer rubrum (Red maple)									0	
Acer saccharinum (Soft or silver maple)					3			2	2 (b)	0
Acer saccharinum (Skinner maple)									2 (b)	
Acer saccharinum (Willis maple)									2 (b)	
Acer saccharinum wieri (Wier maple)									2 (b)	
Acer saccharum (Sugar maple)		3								0
Ailanthus altissima (Tree-of-heaven)				0					0	
Albizzia julibrissin (Silktree)									0	
Betula alba (European white birch)							3			
Betula pendula gracilis (Cutleaf weeping birch)									3 (c)	
Betula sp. (American white birch?)		4 (d)								
Betula sp.? (Birch)					4					
Caragana arborescens (Siberian pea tree)				0						
Castanea sp.? (European chestnut)				0						

TABLE 3.—The degree of drought injury to trees in nurseries in several counties in Kansas in 1934—*Continued*

Species.	Counties in Kansas.									
	Ellis.	Riley.	McPherson.	Sedgwick.	Sumner.	Leavenworth.	Douglas.	Johnson.	Franklin.	Labette.
DECIDUOUS—CONTINUED.										
Catalpa bignonioides nana (Umbrella catalpa)		0								
Catalpa speciosa (Western catalpa)					2				0	
Celtis occidentalis (Hackberry)		1			3	0			0	
Cercis canadensis (American redbud)		2		0					0	3
Crataegus coccinea (Thicket hawthorn)									0	
Crataegus cordata (Washington hawthorn)									0	
Crataegus crusgalli (Cockspur thorn)									0	
Crataegus mollis (Downy hawthorn)									0	
Crataegus oxyacantha (English hawthorn)									0	
Crataegus oxyacantha splendens (Paul double scarlet hawthorn)									0	
Diospyros virginiana (Common persimmon)				0					0	
Elaeagnus angustifolia (Russian olive)		0	0	0				0		
Fraxinus americana (White ash)		0				0			0	
Fraxinus lanceolata (Green ash)								0		
Fraxinus sp.? (Ash)	3				3					
Ginkgo biloba (Maidenhair tree)			2							
Gleditsia triacanthos (Common honey locust)									0	
Gymnocladus dioica (Kentucky coffee tree)	0									
Hicoria pecan (Pecan)				0	4				0	

TABLE 3.—The degree of drought injury to trees in nurseries in several counties in Kansas in 1934—*Continued*

Species.	Counties in Kansas.									
	Ellis.	Riley.	McPherson.	Sedgwick.	Sumner.	Leavenworth.	Douglas.	Johnson.	Franklin.	Labette.
DECIDUOUS—CONTINUED.										
Juglans cinerea (Butternut)									3 (c)	
Juglans nigra (Black walnut)	2			0	4				0	
Koelreuteria paniculata (Golden-rain tree)									0	
Liriodendron tulipifera (Tulip tree)									3 (c)	0
Malus ioensis plena (Bechtel crab)		1							0	
Morus alba (White mulberry)									0	2
Morus alba pendula (Weeping mulberry)									0	
Morus sp.? (Mulberry)					1					
Platanus occidentalis (Sycamore; American plane tree)								0	0	0
Platanus orientalis (European plane tree)									0	
Populus alba richardi (Richards golden poplar)										3
Populus deltoides (Southern cottonwood)				4 (i)						
Populus eugenei (Carolina poplar)				0	4				0	2
Populus nigra italica (Lombardy poplar)		3	0	0	4				0	2
Populus sargentii (Sargent cottonwood)				4 (i)						
Populus sp. ? (Cottonwood)	3				2					
Prunus persica (Flowering peach)									0	
Prunus virginiana demissa (Western choke cherry)									2 (b)	
Ptelea trifoliata (Common hop tree)									0	
Quercus macrocarpa (Bur oak; mossy-cup oak)	3									

TABLE 3.—The degree of drought injury to trees in nurseries in several counties in Kansas in 1934—*Continued*

Species.	Counties in Kansas.									
	Ellis.	Riley.	McPherson.	Sedgwick.	Sumner.	Leavenworth.	Douglas.	Johnson.	Franklin.	Labette.
DECIDUOUS—CONTINUED.										
Quercus maxima (Common red oak)	....	....	0	....	....	....	....	2	0	....
Quercus palustris (Pin oak)	....	2	0	....	....	2	....	....	2 (b)	....
Quercus sp.? (Oak)	....	....	....	....	1	....	....	....	....	....
Robinia hispida (Rose-acacia)	....	....	....	....	....	....	....	....	0	....
Robinia pseudoacacia (Common locust)	....	....	....	....	....	....	....	....	0	....
Robinia pseudoacacia inermis (Thornless locust)	....	....	....	0	....	....	....	....	....	....
Robinia sp.? (Locust)	....	....	....	....	3	....	....	....	....	....
Salix alba x fragilis (Niobe weeping willow)	....	4 (d)	....	....	....	....	....	....	....	....
Salix babylonica (Babylon weeping willow)	....	....	....	....	....	....	....	....	....	3
Salix discolor (Pussy willow)	....	4 (d)	....	....	....	....	....	....	....	....
Salix elegantissima (Thurlow weeping willow)	....	....	....	....	....	....	....	....	....	3
Salix spp. (Willows)	....	....	....	....	....	....	3 (e)	....	....	....
Sassafras variifolium (Common sassafras)	....	....	....	....	....	....	....	....	0	....
Sophora japonica (Pagoda tree; Chinese scholar tree)	....	....	....	....	....	....	....	....	0	....
Sorbus aucuparia (European mountain ash)	....	....	....	....	....	....	....	....	0	....
Taxodium distichum (Common bald cypress)	....	....	0	....	....	....	....	....	0	....
Tilia glabra (American linden; basswood)	....	....	....	....	....	....	....	....	3 (c)	....
Tilia platyphyllos (Bigleaf European linden)	....	....	....	....	....	....	....	....	3 (c)	....
Ulmus americana (American elm)	3	2	3	....	3	2	....	0	0	1

TABLE 3.—The degree of drought injury to trees in nurseries in several counties in Kansas in 1934—*Continued*

SPECIES.	Counties in Kansas.									
	Ellis.	Riley.	McPherson.	Sedgwick.	Sumner.	Leavenworth.	Douglas.	Johnson.	Franklin.	Labette.
DECIDUOUS—CONCLUDED.										
Ulmus americana (Moline elm)	.....	.....	.....	.....	.....	.....	.....	0	0	.....
Ulmus americana (Vase elm)	.....	.....	.....	.....	.....	.....	.....	0	0	.....
Ulmus pumila (Chinese elm; Dwarf Asiatic elm)	1	0	0	0	1	0	.....	0	0	0
Ulmus spp. (Elms)	.....	.....	.....	.....	.....	.....	2	.....	.....	.....
EVERGREEN										
Juniperus canadensis (Prostrate juniper)	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Juniperus chinensis (Chinese juniper)	.....	.....	1	.....	.....	.....	.....	.....	2 (b)	.....
Juniperus chinensis columnaris? (green and blue)	.....	0	.....	.....	.....	.....	.....	.....	.....	.....
Juniperus chinensis femina (Reeves juniper)	.....	.....	.....	.....	.....	.....	.....	.....	0	.....
Juniperus chinensis mascula?	.....	0	.....	.....	.....	.....	.....	.....	.....	.....
Juniperus chinensis pfitzeriana (Pfitzer juniper)	.....	0	.....	.....	4	0	.....	.....	0	0
Juniperus chinensis procumbens (Japanese juniper)	.....	.....	.....	.....	.....	.....	.....	.....	2 (b)	.....
Juniperus pyramidalis (Column Chinese juniper)	.....	0	.....	.....	.....	.....	.....	.....	0	.....
Juniperus communis (Common juniper)	.....	.....	.....	.....	.....	.....	.....	.....	0	.....
Juniperus communis aurea (Golden juniper)	.....	.....	.....	.....	.....	.....	.....	.....	0	.....
Juniperus communis canadensis (Prostrate juniper)	.....	2	.....	.....	.....	.....	.....	.....	.....	.....
Juniperus communis canadensis (Canadian juniper?)	.....	.....	.....	.....	.....	.....	.....	.....	0	.....
Juniperus communis depressa (Prostrate juniper)	.....	0	.....	.....	4	.....	.....	.....	.....	.....
Juniperus communis depressa plumosa? (Andorra juniper?)	.....	4	.....	.....	.....	.....	.....	.....	0	.....

TABLE 3.—The degree of drought injury to trees in nurseries in several counties in Kansas in 1934—*Continued*

Species.	Counties in Kansas.									
	Ellis.	Riley.	McPherson.	Sedgwick.	Sumner.	Leavenworth.	Douglas.	Johnson.	Franklin.	Labette.
EVERGREEN—CONTINUED.										
Juniperus communis hibernica (Irish juniper)		2	1		3				0	1
Juniperus excelsa (Greek juniper)					3					
Juniperus excelsa stricta (Spiny Greek juniper)			1						0	
Juniperus horizontalis (Creeping juniper)									0	
Juniperus horizontalis douglasii (Waukegan juniper)		2							0	
Juniperus horizontalis glauca? (Blue creeping juniper?)									0	
Juniperus japonica (Japanese juniper)		0							0	
Juniperus sabina (Savin juniper)		2			4	2			0	0
Juniperus sabina (von Ehron)									0	
Juniperus sabina tamariscifolia (Tamarix Savin juniper)		0							0	
Juniperus scopulorum (Chandlers silver juniper)		0							0	
Juniperus scopulorum (Colorado juniper)		0	1							
Juniperus virginiana (Red cedar)	0	0	1	0	1				0	
Juniperus virginiana cannartii (Cannart red cedar)		0	1						0	
Juniperus virginiana elegantissima (Goldtip red cedar)		0								
Juniperus virginiana glauca (Silver red cedar)		0	1						0	0
Juniperus virginiana kosteri (Koster juniper)		0								
Juniperus virginiana pyramidiformica hillii? (Hills Dundee?)		0							0	
Juniperus virginiana schottii (Schott red cedar)		0							0	

TABLE 3.—The degree of drought injury to trees in nurseries in several counties in Kansas in 1934—*Continued*

Species.	Counties in Kansas.									
	Ellis.	Riley.	McPherson.	Sedgwick.	Sumner.	Leavenworth.	Douglas.	Johnson.	Franklin.	Labette.
EVERGREEN—CONTINUED.										
Juniperus sp.? (Bar Harbor Juniper)		2								
Juniperus sp.? (Deforest)		0								
Juniperus sp.? (Nevins) (blue)		0								
Juniperus sp.? (Scotts)		0								
Juniperus sp.? (Staghorn?)			1							
Juniperus spp			(f)				(g)			
Picea abies (Norway spruce)		4								
Picea excelsa (Norway spruce)						4	4 (h)			
Picea glauca (canadensis) albertiana (Black Hill spruce)		4					4 (h)		4 (i)	
Picea pungens (Colorado blue spruce)	2 (j)	4	3 (k)						4	
Pinus banksiana (Jack pine)								4		
Pinus densiflora (Japanese red pine)		0							0	
Pinus mugo mughus (Mugho pine)	2 (j)	4	3 (k)			2		2	0	
Pinus nigra (Austrian pine)	3	2	0			0		0	0	
Pinus ponderosa (Western yellow pine)	0	0 (l)	0					0	0	
Pinus strobus (White pine)		4				2		4		
Pinus sylvestris (Scotch pine)	3	4	4			2		0	0	
Pinus thunbergii (Japanese black pine)									0	
Pinus spp.? (Pines, various species)					1					

TABLE 3.—The degree of drought injury to trees in nurseries in several counties in Kansas in 1934—*Concluded*

Species.	Counties in Kansas.									
	Ellis.	Riley.	McPherson.	Sedgwick.	Sumner.	Leavenworth.	Douglas.	Johnson.	Franklin.	Labette.
EVERGREEN—CONCLUDED.										
Pseudotsuga taxifolia (Douglas fir)		4	2							
Thuja occidentalis (American arborvitae)					1		4 (h)		4 (i)	
Thuja occidentalis compacta (Parsons arborvitae)		0								
Thuja orientalis (Oriental arborvitae)	0	0				0			0	
Thuja orientalis (Bakers arborvitae)		0	0						0	3
Thuja orientalis aurea (Golden oriental arborvitae)						0				
Thuja orientalis aurea conspicua (Goldspire arborvitae)		0	0		1					2
Thuja orientalis aurea nana (Berckmans golden arborvitae)		0	0	0	1				0	1
Thuja orientalis compacta (Siebold arborvitae)			0							2
Thuja orientalis excelsa? (excelsa?)		0	0						0	1
Thuja sp. (beverleyensis?)		0								
Thuja sp.? (Bonita)										1
Thuja sp. (meldensis?)		0								
Thuja sp.? (Nelsons pyramidal arborvitae)			0							

(a) 0, no injury; 1, very slight injury; 2, slight injury; 3, severe injury; and 4, very severe injury
(b) Burning and dropping of foliage.
(c) Trees sunscalded on trunk and branches.
(d) From 75 to 100 percent.
(e) Some a total loss.
(f) A large list of Juniperus varieties, "upright grafted stock," and a large list of Juniperus varieties, "prostrate stock," had no injury in all except two cases of slight injury.
(g) Practically all varieties withstood the drought without injury.
(h) *Picea excelsa*, *Picea glauca*, and *Thuja* spp. were injured the most severely of all evergreens.
(i) Killed.
(j) Burning of lower limbs.
(k) Ten percent loss.
(l) Withstood drouth best of all pines.

An examination of the information on injury in the various counties shows one that the injury in eastern Kansas was less than that in east central or central Kansas. This is as one might expect from the environmental conditions which prevailed in 1934. In other parts of the state one notes that certain species have been injured to a greater degree than others, while a few species have consistently appeared with "no injury." The reaction of certain species, such as the red cedar, confirm the general belief and observation that it withstood dry weather to a marked degree. On the other hand, the notes on other species present evidence of susceptibility to drought injury to a degree which has not been known or suspected.

An attempt was made to tabulate the data so as to show the reaction of the various species in definite sections of the state. Numerous difficulties, however, are encountered when this is attempted, and one is unable to do this with any degree of certainty. For this reason, only a few species stand out in any given section of Kansas as consistently reacting in a definite manner. These are listed below:

East Central Kansas

(Data from 3 or more counties)

Deciduous Trees (no injury):
- *Elaeagnus angustifolia* (Russian olive)
- *Ulmus pumila* (Chinese elm; Dwarf Asiatic elm)

Evergreen Trees (no injury):
- *Juniperus virginiana* (Red cedar)
- *Thuja orientalis aurea nana* (Berckmans golden arborvitae)

Eastern Kansas

(Data from 3 or more counties)

Deciduous Trees (no injury)
- *Ulmus pumila* (Chinese elm; Dwarf Asiatic elm)

Evergreen Trees (no injury):
- *Pinus nigra* (Austrian pine)

The red cedar showed no injury in the eastern section of Kansas in as far as observations and records are available. It is not mentioned above because it was not grown in 3 or more nurseries which were used in these studies. The two nurseries that did grow red cedar reported "no injury." Western yellow or ponderosa pine was found in 6 nurseries, and in no case was there injury. The six trees found in the surveyed area of Manhattan were all apparently uninjured. It was by far the outstanding example among the pines.

These studies indicate that Chinese elm is somewhat more drought resistant or less injured by heat than the American elm. It will be seen that these same general conclusions were reached in the survey made in Manhattan for Chinese elm and red cedar. The Russian olive withstood the drought very well.

The injury sustained in soft maple, Scotch pine, Colorado blue spruce, and black walnut was equally severe in the nurseries and in Manhattan.

The severe injury to the cottonwood, Lombardy poplar, and several species of willow was unexpected.

WHAT TREES SHOULD BE PLANTED

The writers have presented these data chiefly because of their scientific interest. These studies have not been made with the idea of drawing final conclusions. No attempt is made to recommend one species as the desirable one to grow in Kansas, nor is it possible to say with any assurance that one species should replace another because of drought resistance. Kansas has Scotch pine, white pine, and willows that have withstood the wintry blasts and summer heat for over 50 years. This is reason enough that these species as well as others, even though hard hit by the drought of 1934, should be planted again to grace Kansas with their beauty. It should be so with other species of trees that have been injured by the severe drought. It may be many years before another disastrous prolonged drought will appear in Kansas. The fact that Chinese elm has shown somewhat more drought resistance than American elm is no reason for saying that it should replace the American elm or has any superior qualities. The Chinese elm has some undesirable characteristics and there is much we do not know about its value in Kansas.

SUMMARY

The record-breaking temperatures, together with a pronounced shortage of moisture, made 1934 one of the most disastrous years ever known in Kansas for crops and vegetation in general. These conditions made it possible to study the effect of drought and heat on trees in Kansas.

A survey of all the trees in a definite area (253 acres) in the city of Manhattan, Kan., during the summer of 1934 showed that about 20 percent of the trees were dead or dying, and an additional 30 percent were definitely injured as a result of the drought and heat. About 50 percent were apparently uninjured.

In the parts of the city containing natural or wild areas, 24 percent of the trees were dead or nearly dead, and 47.5 percent were apparently still sound. In an older, poorer section, 36 percent were dead or nearly dead, and only 26 percent uninjured. In a newer, better-watered section, only 8 percent of its trees were dead or nearly dead and 66 percent still sound.

The white elm comprised about one third of all the trees in the surveyed area. Although 28 percent were watered, 22.5 percent died, and 41 percent were apparently uninjured by the heat and drought. The canker-worm injury was severe on the elm and allowance for this damage is made in this study.

Of the 75 species occurring in the surveyed area, the red cedar is next to the elm in number of individuals. Arborvitae (oriental), soft maple, hackberry, cherry, and black walnut follow closely.

The species most widely distributed in Manhattan were white elm, black walnut, hackberry, Chinese elm, red cedar, and mulberry.

The soft maples and pin oaks were watered the most. The black locust, mulberry, and boxelder were watered the least.

Table 2 shows the more popular trees arranged according to their drought resistance. The red cedar, tree-of-heaven, arborvitae, pear, and hackberry head the list in the city of Manhattan. White elm, pin oak, soft maple, black walnut, Scotch pine and the willows are less drought resistant.

On the basis of the 253 acres, or 15.6 percent, the area surveyed, Manhattan

had about 50,000 trees. It is believed that of this number, about 10,000 died because of the heat and drought.

A study on the effect of heat and drought on trees was made in ten nurseries in three areas of Kansas. In most instances a very close correlation exists between the reaction of certain species to drought in the surveyed area of Manhattan and the same species in nurseries.

The red cedar among the evergreens and the Chinese elm among the deciduous trees were reported uninjured in three or more counties in eastern and east central Kansas. Berkmans golden arborvitae in east central Kansas and Austrian pine in eastern Kansas were uninjured. In each nursery the western yellow or ponderosa pine withstood the drought the best of all the species of pine.

The general conclusions reached on the injury sustained by the soft maple, Scotch pine, American elm, and black walnut in Manhattan are in accord with the injury occurring in nurseries.

The Chinese elm seemed to be less injured by the heat and drought than the American elm. The Russian olive withstood the drought very well.

The very severe injury to the cottonwood, Lombardy poplar, and several species of willow in the nurseries, and of some of these species along the dried stream beds in Kansas, was distinctly a surprise.

Such species as American white birch, pussy willow, white pine, jack pine, Colorado blue spruce, and Black Hill spruce, were very severely injured in certain counties, as shown in table 3.

It is believed that some evidence has been presented to show that the heat and drought of 1934 have injured and killed certain species of trees to a greater degree than other species. Nevertheless, there is reason enough that the susceptible species should be planted again in favorable locations and in sufficient numbers, because it may be many years before another equally severe drought will occur in Kansas.

A New Method for the Preparation of Anhydrous Acetates

MYRL R. ADAMS and ARTHUR W. DAVIDSON, University of Kansas, Lawrence, Kan.

Although anhydrous acetates of the alkali and alkaline earth metals are readily prepared by the crystallization of the hydrated compounds from aqueous solution and their subsequent dehydration at high temperatures, this simple process is not generally applicable to the acetates of less positive metals, since such salts often undergo considerable hydrolysis or decomposition, or both, during the dehydration, which results therefore in the formation of decidedly basic products. The alternative procedure of dehydration by means of a desiccating agent at ordinary temperature is not always successful, and is in any case excessively tedious.

In the method to be described here, these difficulties are avoided by the preparation of acetates in the entire absence of water. It consists, in brief, of subjecting the metal in question to anodic oxidation in an electrolyte of an alkali metal acetate in solution in anhydrous acetic acid. Since the solubilities of most of the heavy metal acetates (except that of lead) in this medium are not very large, good yields of nearly pure salts are often obtainable. In a previous paper from this laboratory (1), it was reported that mercurous acetate was formed practically quantitatively in the electrolysis of a solution of sodium acetate in acetic acid with a mercury anode. In the present work the anodic oxidation of zinc, iron, copper and aluminum in similar media was studied.

The electrolyses were carried out in a 150 c.c. lipless beaker, sealed with a rubber stopper through which passed a stirrer, a rod of the metal to be used as anode, and a glass tube containing a little mercury, through which electrical contact was made with the sealed-in cathode of platinum foil. In most of the experiments the anode was placed inside a porous cup of unglazed earthenware; an inverted glass U-tube, suspended over the edge of the cup, served as a siphon to maintain the same level of liquid inside the cup as outside. The cell was immersed in a water bath to prevent excessive rise of temperature. The source of direct current was a modified Majestic "B battery eliminator," the voltage being regulated by a rheostat connected across the alternating-current input. The secondary (direct-current) circuit contained a milliammeter in series with the electrolytic cell.

The acetic acid was dehydrated by the method of Kendall and Gross (2), and the anodes were of the purest metals obtainable.[1]

A typical electrolysis was carried out as follows. After cleaning and weighing the zinc anode, the cell was assembled as described above, and was filled with a 10 percent solution of sodium acetate in acetic acid. The electromotive force was adjusted to give a constant current of 50 milliamperes, which required about 280 volts. The electrolysis was continued for 12 hours, after which the anode was removed and weighed. The salt formed in the cup was removed with a spatula and placed between porous tiles over solid

1. We wish to express our gratitude to the Aluminum Company of America for an aluminum rod of high purity (99.97% Al), which was used in this study.

sodium hydroxide in a desiccator, where it was allowed to remain for a week. Finally, it was heated to constant weight in an oven maintained at 85° C. The dry product was then analyzed for zinc by titration with standard potassium ferrocyanide solution.

With an iron anode the procedure was, in general, the same; ammonium acetate, however, instead of sodium acetate, was used as electrolyte. The product was freed from acetic acid by keeping it over sodium hydroxide in a vacuum desiccator until it attained constant weight, which required about two weeks. Qualitative tests showed the iron in this salt to be entirely in the ferric state.

With copper, sodium acetate solution was used as electrolyte. Considerable pitting occurred during the electrolysis, and the product, which was readily dried at 85° C., was contaminated with about 2 percent of insoluble material. The water-soluble portion consisted not of pure cupric acetate, but of the solvate $Cu(C_2H_3O_2)_2 \cdot HC_2H_3O_2$, first reported by Sandved (3).

With aluminum as anode, the method had to be modified in several respects in order to obtain satisfactory results. The porous cup was omitted, and the anode was placed in the center of the cell and surrounded by a cylindrical sheet aluminum cathode of large surface, the distance between the electrodes being about 2 cm. The surface of the anode was rendered active by repeatedly heating the rod and plunging it into hot 40 percent nitric acid just before use. The electrolyte consisted of a 2 percent sodium acetate solution, and the temperature was maintained at 55° C. The source of current for the electrolysis was the regular laboratory 110-volt direct-current circuit, with a rheostat serving as potential divider; the voltage was adjusted to give an anode current density of 2.5 milliamperes per sq. cm. After removal of most of the liquid from the product by rapid filtration on a Buchner funnel, the still wet salt was dried by pressing between porous tiles and then exposing in a desiccator over solid sodium hydroxide for a week.

The results are summarized briefly in the following table.

Metal	Anode current density, milliamp. per sq. cm.	Yield of salt, percent of theoretical[2]	Percent of metal in salt	
			Theoretical	Observed
Zn	7.0	85	35.64	35.65
Fe	10.0	90	23.98	23.73
Cu	13.0	65	26.31[3]	25.30
Al	2.5	85	13.23	12.3–13.7

2 Based upon quantity of electricity used.

3. For $Cu(C_2H_3O_2)_2 \cdot HC_2H_3O_2$.

It seems probable that the method here described might be extended to the preparation of a number of other acetates.

LITERATURE CITED

1. Davidson and Holm: Univ. Kans. Sci. Bull., *21*, 463 (1933).
2. Kendall and Gross: J. Am. Chem. Soc., *43*, 1426 (1921).
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A Study of Oil-well Brine Disposal

EARNEST BOYCE, University of Kansas, Lawrence, Kan.

The development of adequate water resources for the Mid-Continent area of the United States presents certain problems that are peculiar to an interior region. Coastal states with population centers between the highland water catchment areas and the ocean find it possible to secure a practically pure water from sparcely inhabited collection areas and to dispose of the used water with comparative ease into the ocean or rivers not needed for use as sources of water supply.

Uninhabited areas that can be developed for water catchment are not available in the Mid-Continent region. Surface streams must provide the major source of municipal water supply and at the same time serve as the natural drainage channels of the valleys through which they pass. Uncontaminated sources of surface water are not geologically or economically possible. While ground water storage is sufficient for the requirements of many small cities, unfortunately, from a water resource standpoint, extensive industrial development has taken place in areas where the underground storage is wholely inadequate to yield supplies large enough to meet community and industrial demand.

Since the streams that provide the natural drainage must receive the domestic and industrial wastes of the tributary area and at the same time serve as the source of water supply for the lower valley, it follows that these streams must be maintained in such physical and chemical condition that potable water can be produced with the aid of modern water-treatment processes.

The need for conserving the surface-water resources of the Mid-Continent is evidenced by the fact that in Kansas approximately 24 percent of the population of the state are dependent on surface-water supplies for domestic use. The streams thus become an important part of the natural resources of the state, and their protection against irreparable damage a major problem.

In the planning of the industrial and economic development of a region the resources that are essential to that development must be taken into consideration. Unless an adequate supply of water suitable for use is available the limitation of the water resources easily becomes the controlling factor in the industrial and agricultural development of a given area.

The value of our water resources may be expressed both in terms of quantity and quality of water available for use. The quantity of water is controlled by the amount reaching a given drainage basin as rain or snowfall, its monthly and annual distribution and the natural and artificial storage provided above and below ground in the given area.

The quality of surface water passing through a drainage basin is dependent on natural geologic factors modified by the development of the watershed by cultivation, deforestation and other changes of the soil covering that tend to increase the soluble and insoluble mineral matter carried by the stream. The quality is also dependent on the character of the liquid organic and

inorganic waste incident to the development of the valley. Adequate stream sanitation should reduce to a minimum the permanent effect of the organic wastes reaching the stream. There is no cause to question or discuss the effectiveness of a properly designed and operated modern sewage-treatment plant to so change the character of the organic wastes reaching the plant that a reasonable reuse of the water in the receiving stream is possible.

This paper is concerned with the problem of disposal of liquid wastes incident to oil production, commonly referred to as oil-field brines. These wastes are, for the most part, chemically and biologically inert, but because of the concentration of mineral salts present, their discharge into streams that must continue to serve down-valley cities and industries creates a serious problem of water-supply contamination.

Because of the mineral nature of these brines, they do not change except in intensity of concentration. Unless there is water available for adequate dilution the concentration of mineral salts, principally the chlorides of calcium, magnesium and sodium, may become great enough to destroy the usefulness of the stream for purposes other than waste disposal. Confined to ponds these wastes, due to their seepage into ground-water formations, often threaten the quality of well-water supplies.

In order to give some idea of the highly mineralized nature of some brines produced in the Mid-Continent field, the accompanying table of analyses of five typical Oklahoma brines is included. This is from the Report of Investigations, U. S. Bureau of Mines No. 2,945.

ANALYSES OF WATER SAMPLES OBTAINED FROM SELECTED REPRESENTATIVE PRODUCING AREAS IN OKLAHOMA

Radicals	Sample 1 p. p. m.	Sample 2 p. p. m.	Sample 3 p. p. m.	Sample 4 p. p. m.	Sample 5 p. p. m.
Calcium	10,763	5,530	4,708	12,822	1,254
Magnesium	3,691	1,625	1,939	2,748	396
Sodium	76,915	36,914	34,058	75,400	12,229
Carbonate	.....	.....	.....	.....	.....
Bicarbonate	31	177	.....	92	119
Sulfate	348	2	44	184	8
Chloride	145,244	71,361	66,486	146,804	22,161
Total solids	235,982	115,609	107,235	238,045	36,167
Specific gravity at 60° F.,	1.162	1.081	1.076	1.162	1.026

From these analyses it will be noted that sodium, calcium and magnesium chlorides predominate; not infrequently smaller amounts of rarer salts are found, including iodides, bromides and barium salts. It is of interest to note that the total solids in Sample No. 4 in the table total approximately 2 pounds per gallon. Due to the mineral inertness of the compounds in solution, no treatment method can be applied to remove or greatly modify the objectionable characteristics of the brines. When we compare the concentrations of these brines with the limits of potable drinking water as recommended by the U. S. Public Health Service, the pollutional effect of the brines becomes apparent. On the basis of total solids the maximum value in the U.S.P.H.S. standards is 1,000 p. p. m. as compared with the value 238 times as great observed in Sample No. 4.

Chlorides should not exceed 250 p.p.m. as compared with 146,804 p.p.m. in Sample No. 4 or 587 times the permissible limit.

The U.S.P.H. standard maximum limit value of magnesium of 100 parts per million has been exceeded 27 times in this sample. From this comparison as well as others that have formed the basis of complaint from oil-field pollution, it is evident that the chloride concentration is the first to become objectionable. Assuming that a well produces brine of a concentration comparable with the above sample and at a rate of 1,000 barrels per day, a flow of chloride-free water at a rate of 47.4 c.f.s. would be required to dilute the brine to prevent an excessive chloride content in the receiving stream.

It is interesting to note that one Mid-Continent field produced a total of 43,393 tons of chloride salts in the 12-month period ending November 1, 1933. If this amount of salt were to be diluted so that the mineral content would not be increased more than 10 grains per gallon, it would require a continuous discharge of 3,000 barrels per minute of diluting water.

In another field, covering approximately 35 square miles and located in a valuable farming region, the salt production totals approximately 400 tons per day. In this case the brine disappears by seepage from lease ponds into an important underground fresh-water formation.

In order to better understand the problem of brine production and to better visualize the geological conditions which make its control difficult, this paper will review briefly the occurrence of brine in a producing oil field. The brine is pumped to the surface with the oil and becomes a waste product when separated from the oil by gravity in field tanks.

The brine brought to the surface with the oil may have its origin in the rock overlying the impervious formations against whose under surface the oil and gas have collected, or it may come from the formations that underlie the oil horizon, or it may be a mixture of both top and bottom water.

The significance of oil-field brine is indicated by the fact that most wells are abandoned while they are still capable of producing some oil, but due to the increased proportion of brine to oil pumped to the surface further operation ceases to be economical. The economic limit of the oil to water ratio that will permit continued operation depends on the cost of maintenance and pumping, the cost of brine separation and disposal, and the value of the crude petroleum produced.

Petroleum geologists have estimated that by the commonly used methods of flowing and pumping, less than half of the oil is recovered from producing formations. The subsurface movement of oil-field brines plays an important part in controlling the life of a producing field. Movements of salt water are created by an unbalancing of pressure due to the removal of gas, oil and salt water incident to the development of the field. Movement must of necessity be toward areas of reduced pressure, *i.e.*, the area of oil-producing formation. The path of travel may be either through natural faults, fissures, solution channels, openings made by drill holes, or through the interstices between sand grains displacing the oil in the direction of the reduced pressure area centering about the well being pumped.

Due to the lesser specific gravity of oil as compared with salt water it has a tendency to move upwards toward the surface of the ground until stopped

by gas-locked passages or impervious formations. Hence, it is logical to presume that in general no natural openings exist for the escape of oil or the entrance of salt water except on the edges of the impervious cap rock, below the bottom of the oil-water horizon. The migration of salt water from formations of higher to those of lower pressure, through imperfectly cased producing wells or carelessly plugged abandoned drill holes, is guarded against by laws and by the coöperative effort of those oil companies that appreciate the dangers of such salt-water migration.

Migration of brines from higher formations to lower oil-producing formations may be expected to occur naturally in most fields as the oil is removed from below the impervious rock. It is important to note, however, that it must enter the oil-producing formation below the original oil-water horizon if it enters through natural passages. Failure to confine top-water formations during the drilling of a well may result in a movement of the water downward to the bottom of the well, permitting it to enter the casing with the oil. Excess water entering the oil formation through a well will tend to flood the oil formation, thus reducing the volume of available oil, and may become a primary cause for abandoning the well. Improved methods of well-drilling, including the cementing of the annular space between the casing and the drill hole, have greatly reduced this salt-water hazard in properly drilled new wells, and to a limited extent have made possible the reconditioning of existing wells resulting in an increase in oil production and a decrease in the salt water.

The production of an increased flow of salt water from a well when pumping is resumed following a shutdown is evidence that the removal of oil has created an unbalanced hydraulic condition in the water- and oil-producing formations, and that static stabilization has required an oil and water migration. In some cases static stabilization is produced by a downward movement of the top water through the opening made in the cap rock by the drilling of the well with the consequent flooding of the producing formation. Any leakage of top water through the cap rock into the oil-producing formation adds to the water pumped to the surface along with the oil. Proper repairs greatly reduce the salt-water production of such wells. If the hydraulic stabilization could be limited to water movements through natural openings, the movement would be from below and from the side of the oil formation with a minimum disturbance of the oil-water horizon.

The second source of salt water in a producing well is from the formation underlying the production horizon. This may be caused by the drill hole penetrating too far into the oil-producing formation, making it possible for the bottom water to enter the well with less resistance than the oil, or by pumping at a rate greater than the rate of oil movement to the well, thus causing the bottom water to rise (usually referred to as "coning"). In the first case, bottom plugging has been useful in reducing the volumes of water pumped and in the second case a reduced pumping rate is indicated. Unfortunately the source of water may be difficult to trace. Brines that have had long contact with oil formations may have distinctive modifications that identify them from water coming from top formations. This modification is usually indicated by a marked reduction in sulphate content as compared with other deep-seated waters in the same area, a change that has been attributed

to a reducing action of the petroleum compounds. Regardless of the salt water that may enter a well due to imperfect construction or improper operation, in most fields bottom water may be expected to rise under hydrostatic head as the oil is pumped and eventually reach the well as the center of the reduced pressure in the oil formation. Therefore increased salt-water production may be anticipated in most oil fields as the available oil is depleted and its appearance does not of necessity indicate improper development. From this brief review it is evident that most oil-producing areas sooner or later have to solve the problem of oil-field-brine disposal.

The character of the mineral salts contained in the waste water from oil wells makes it impossible to modify these brines chemically to a point where the water would be usable. Since the salts are objectionable largely because of their concentration, dilution with fresh water is a possible method of disposal.

Satisfactory disposal by dilution requires that there must be adequate flow in the stream at all times. There are two ways of doing this: First, by holding the wastes in reservoirs until the natural flow of the stream will give adequate dilution, and second, by increasing the dry-weather flow of the streams by a controlled discharge of fresh water impounded above the source of these mineral wastes.

The big difficulty in the problem of releasing mineralized waters stored during periods of low flow is the lack of adequate control authority to give permission to discharge. There must be definite information available regarding river stages in order to know how much mineral waste can be disposed or by dilution. Stream-flow measurements and rainfall data must be obtained and made immediately available to some responsible authority whose duty it would be to control the discharge of these wastes.

The amount of water available in the average Mid-Continent stream draining oil-field areas during the periods of low flow does not approach the amount required to provide adequate dilution to the oil-field brine produced. This condition first becomes evident in upper tributaries where channels are dry except for storm-water flow. The failure to secure adequate dilution from natural run-off is most acute in the immediate vicinity of a producing oil field, but as a period of low rainfall and runoff continues the diluting effect downstream of the flow from the larger drainage area fails to reduce the concentration to potable limits. Further, channel storage in the streams near the oil fields becomes filled with an increasing concentration of brines. If this concentration of brines is removed during quick, heavy flood a dilution may be secured that will avoid complaint. If the flood is slight it may displace the channel storage downstream without adequate dilution and give cause for complaint at points at considerable distance from the oil-field source.

In order to make use of the dilution effect of flood water and thus avoid complaints and damage suits from riparian claimants using the surface water receiving oil-field drainage, many oil companies have made use of salt-water ponds for storage and evaporation. Where the surface water is to be protected, the use of ponds from the controlled discharge of salt water during periods of flood in the receiving stream would seem to be a satisfactory method of disposal by dilution.

Coöperative agreements between producers make possible the construction of large salt-water storage reservoirs, into which all the salt water produced in the field is pumped and from which it may be discharged, under control, to maintain satisfactory dilution conditions in the receiving stream. While it may be that the total cost of storage in large reservoirs will be more than the cost of storing the salt water on individual leases, the need for an adequate control of the discharge into the receiving stream makes storage in large reservoirs desirable.

In Kansas the only large-scale storage for disposal of mineral water by dilution is located at the refinery of the Standard Oil Company of Kansas at Neodesha. Here a reservoir covering 65 acres can be filled to a depth of from 12 to 14 feet and provides storage for the waste water from the refinery for one year. This has successfully controlled objectionable pollution from this source of the river water supplies of Cherryvale, Independence and Coffeyville for the past ten years. Seepage is effectively controlled by trenching around the reservoir and repumping.

While solar evaporation offers a possible method of brine disposal, actual rates of evaporation have not been fully studied and many operators do not differentiate between evaporation and seepage. Unfortunately, seepage is hard to control and sites for adequate storage are difficult to find and expensive to develop.

Aside from field evaporation or controlled discharge into adequate volumes of diluting water, two other methods of brine disposal may be considered. First, the evaporation of brines under plant conditions for the recovering of mineral salts; and second, the return of the brines to underground formations.

The use of oil-field brines as a source of mineral salts of commercial value offers possible revenue. Experience with brine evaporation for the production of a commercial product has been tried at Sand Springs, Okla. From available data it would seem that this method is feasible only if the brines contain sufficient amounts of the rarer salts. It is possible that the revenue from the sale of salts recovered from concentrated brines may be used to offset part of the cost of brine disposal, and that the net cost may compare favorably with other methods of disposal.

The return of oil-field brines to geological formations that are normally filled with highly mineralized water is a method of disposal that warrants careful study and consideration.

The removal of oil and salt water from producing formations must of necessity leave the rock openings, formerly filled by the pumped oil and water, filled either with gas or with water that has moved into the space under hydrostatic head. While in some geologic formations there is evidence that the removal of petroleum results in a compacting of the producing formation due to the pressure of overlying formations, there is little evidence that the oil-producing formations of the Mid-Continent area are so compacted. Unless these formations are reduced in volume, it follows that salt water might be returned to the oil-producing sands, for it is obvious that the salt water is of less volume than the salt water and oil pumped from the well. Solar evaporation from ponds might be useful in reducing the volume and increasing the concentration of brines before their return to salt-water formations. If we accept the theory that the brines underlying the oil rises in the structure as the

oil and gas are removed, it follows that at some point an equal volume of water might be added to replace the brine that has moved into the producing formation without disturbing its hydrostatic balance. When the gas pressure of a new field has been exhausted, the water and oil will seek a static level in the well which, when corrected for density difference, is the top of the ground-water table connecting with the bottom water holding the oil perched inversely beneath some impervious formation.

Any geological study of the possibility of underground brine disposal should be located on the side of the structure and far enough removed that unbalanced water pressure over the producing area would be avoided. While some attempts to return salt water to underground formations have not been successful, there is reason to believe that most of the difficulties encountered have a workable solution.

A number of companies have been able to salvage wells located at the side of the oil-producing structure for brine input use. Failures have occurred where the return rate and pressure have been excessive. For example, one well was operated at a rate of 10,000 barrels per day of brine return with well head pressures up to 1,000 pounds per square inch. The excessive return rate and pressure resulted in the migration of brines to fresh water and dry formations with considerable inconvenience and damage. In one Kansas field a properly cemented well has been used successfully for brine return to a depth of 2,300 feet for approximately two years and is still in successful operation.

Further investigation of this method of handling salt water should be by those having a thorough knowledge of the movements of underground waters as related to the geology of each particular field investigated.

When brine input wells are located and constructed primarily for that purpose it is reasonable to suppose that the results obtained will be greatly improved.

In seeking a solution of the problem of brine disposal, we should study the situation existing or anticipated in each field and apply the methods of disposal that are best adapted to that particular area. Failure to plan for the disposal of anticipated brine production invites expensive litigation and damage suits—and money paid in damages does not restore destroyed water resources.

Fortunately for Kansas water resources, the state legislature has recognized the importance of giving attention to the methods of brine disposal and has provided financial support for research studies of this problem by authorizing a special tax against the petroleum produced in the state. These studies have been favorably accepted by the major operators who recognize that the financial burden of damage suits that threaten the industry can be avoided best by adopting some plan of brine disposal that will prevent damage to the riparian claimants of the water resources of the state.

The Electronegativity of Organic Radicals

R. Q. BREWSTER, University of Kansas, Lawrence, Kan., and W. W. FLOYD, Ottawa University, Ottawa, Kan.

In 1887 Victor Meyer made the first systematic classification of organic radicals into positive and negative divisions. He considered any radical to be negative if its hydroxy derivative would form a salt with sodium hydroxide or if its amino derivative were less basic than ammonia. Thus the phenyl radical was classed as negative and the methyl, or other paraffin radical, as positive. Many inconsistencies could be pointed out in this method of determining the character of each radical, however, especially when the electrical valence of the groups was considered. For example, Meyer called the NO_2 group highly negative, although electrically it actually has one unit of positive charge. Also the phenyl group in benzene appears to be negative, as Meyer postulated, but must be electropositive in phenol and the phenyl halides. Innumerable such irregularities exist in this original classification, and as the field of organic chemistry has grown the need for another basis of characterizing various radicals has become imperative.

The electronic theory of valence, although denounced by Berzelius a century ago as not applicable to carbon compounds, has of recent years been shown to offer many advantages in the explanation of organic reactions. Just as every element has a certain tendency to attract or repel electrons, so may each organic radical exhibit this property. One radical (R) which has a strong attraction for electrons could therefore be written (R :). This radical would be much more negative than another radical (R) which repels electrons and is consequently written (R :). Such a characterization represents perhaps the fundamental difference in various radicals. Thus phenol (C_6H_5: O: H) furnishes a greater concentration of hydrogen ion than methyl alcohol (CH_3: O : H), because in the former case the shift of electrons is toward the carbon-containing radical with a correspondingly greater ease of separation of the proton. Moreover, if the reaction of phenol and of methyl alcohol with hydrochloric acid be considered, it will readily be seen that the repulsion of electrons by the methyl group makes the replacement of the hydroxyl radical ($:\ddot{\underset{\cdot\cdot}{O}}:H$) much easier in methyl alcohol than phenol.

From this point of view it is apparent that if all of the common organic radicals could be allocated as to their tendency to attract or repel electrons, a fundamental principle on which reactions could be explained and predicted would be established. Much work in this field has already been done. Among other contributions, the work of Dr. J. F. Norris[1] and of Dr. M. S. Kharasch[2] are here mentioned.

Various investigators, however, have not obtained results which place the radicals in the same order. In fact different reactions and different experimental conditions have produced a wide variety of results. Hence it is

1. Norris: J. American Chem. Soc. 47; 1925; 837. Ibid., 49; 1927; 2640. Ibid., 52; 1930; 735, 5066. Ibid., 54; 1932; 2088.

2. Kharasch and Flenner: J. American Chem. Soc. 54; 1932; 674.

to be expected that only from a large list of data on different types of experiments can the average or normal position of any radical in the table be finally fixed. With this object in view we offer our results toward the ultimate goal of finding an order of organic radicals which would be comparable to the electromotive series of the metals.

EXPERIMENTAL PART

Phenyl-urethane reacts with aniline when heated at 170-180° for several hours, producing ethyl alcohol and diphenyl urea. Since the diphenyl urea is very slightly soluble in the usual solvents it is easily separated from the soluble products and readily gives an accurate measure of the extent of the reaction. By making a series of experiments in which the ethyl radical is successively replaced by methyl, propyl, etc., the relative ease of replacement of these alkyl groups can be determined from the percentage yield of diphenyl urea in each case.

$$C_6H_5NH\text{-}COOR + C_6H_5NH_2 = ROH + C_6H_5NHCONHC_6H_5$$

This equation may be written in more general terms:

$$RNHCOOR + RNH_2 = ROH + RNHCONHR$$

Any one of the three radicals may be varied while the other two are held constant, hence several series of tests may be performed upon the same basic experiment. Wherever practical these variations were made and the results of four series of experiments are reported.

All of the urethanes used were prepared by the action of phenyl isocyanate upon carefully fractionated and dried alcohols or from the aniline and the alkyl chlorocarbonates. All of the products were twice recrystallized from ligroin and showed the melting points recorded in the literature. The aniline and other aromatic amines used in the reaction were freshly distilled before use.

PROCEDURE

SERIES I

Since all of the experiments must be performed at the same temperature a large oil bath was fitted with an electric heater, regulator, and mechanical stirrer, so that the bath was maintained at a temperature of 175° with a variation of less than 0.5°. The bath was of such size that 12 to 15 experiments could be run at one time. The phenyl urethanes (0.02 mole) were weighed into pyrex tubes 1.6 cm. in diameter and 35 cm. in length, 0.02 mole of aniline added from a pipette, and the tubes placed at once into the oil bath (regulated at 175° C.) where they remained for three hours. At the end of this reaction period the tubes were removed from the bath, cooled as quickly as possible and the solid diphenyl urea washed out upon a suction filter with small portions of ether. A total of 50 c.c. of ether was used in each case. Separate experiments showed that this method of washing caused a loss of 0.12 g. of diphenyl urea. This solubility correction of 0.12 g. was added, therefore, to the yield of diphenyl urea obtained in each experiment. The residue of diphenyl urea was shown to be practically pure by its melting point of 235°.

The following table shows the yield of diphenyl urea obtained when the

phenyl urethanes were heated with aniline at 175° C. for three hours. Since 0.02 mole of each reactant was used in each case the theoretical yield of diphenyl urea would be 4.24 g.

TABLE I

$$C_6H_5NHCOOR + C_6H_5NH_2 = ROH + C_6H_5NHCONHC_6H_5$$

0.02 mole of components. Temp., 175°. Time, 3 hours.

R	Weight of diphenyl urea	R	Weight of diphenyl urea
CH_3	1.68; 1.69	C_4H_9 (iso)	1.16; 1.14
C_2H_5	1.46; 1.46	C_4H_9 (sec)	1.14; 1.17
C_3H_7 (n)	1.30; 1.29	C_4H_9 (ter)	0.94; 0.96
C_3H_7 (iso)	1.27; 1.30	C_5H_{11} (n)	1.18; 1.17
C_4H_9 (n)	1.22; 1.21	C_7H_{15} (n)	1.10; 1.10

SERIES II

The second series of experiments differed from the first in three particulars. (1) the variable radical (R) was aromatic instead of aliphatic, (2) the temperature of the bath was reduced to 140° and (3) the duration of the experiment was 1½ hours. The lower temperature and shorter time were necessary because the aromatic radicals were so much more easily replaced that all gave quantitative yields when heated at 175° for three hours as in Series I. Table II shows the results obtained.

TABLE II

$$C_6H_5NHCOOR + C_6H_5NH_2 = ROH + C_6H_5NHCONHC_6H_5$$

0.02 mole of components. Temp., 140°. Time, 1.5 hours.

R	Grams of diphenyl urea	R	Grams of diphenyl urea
C_6H_5	3.79; 3.88	$CH_3C_6H_4$ (o)	2.33; 2.30
Cl-C_6H_4 (o)	4.15; 4.12	$CH_3C_6H_4$ (m)	3.30; 3.31
ClC_6H_4 (p)	3.96; 3.88	$CH_3C_6H_4$ (p)	2.20; 2.16
$NO_2C_6H_4$ (o)	4.20; 4.18	$CH_3OC_6H_4$ (o)	3.80; 3.82
$NO_2C_6H_4$ (m)	4.10; 4.20	$CH_3OC_6H_4$ (p)	2.08; 2.09
$NO_2C_6H_4$ (p)	3.94; 3.83		

SERIES III

In the third series of experiments the aromatic radical on the nitrogen atom of the urethane molecule was varied. The reaction could be formulated as shown in Table III. The standard procedure as described under Series I was used.

TABLE III

$$RNHCOOC_2H_5 + C_6H_5NH_2 = C_2H_5OH + RNHCONHC_6H_5$$

0.02 mole of components. Temp., 175°. Time, 3 hours.

R	Grams of disubstituted urea	R	Grams of disubstituted urea
C_6H_5	1.46; 1.46	$CH_3C_6H_4$ (m)	0.92; 0.97
ClC_6H_4 (o)	1.58; 1.64	$CH_3C_6H_4$ (p)	1.11; 1.11
ClC_6H_4 (m)	1.32; 1.32	$CH_3OC_6H_4$ (o)	0.31; 0.33
$NO_2C_6H_4$ (o)	1.20; 1.18	$C_2H_5OC_6H_4$ (o)	0.33; 0.30
$NO_2C_6H_4$ (p)	1.16;	$C_2H_5OC_6H_4$ (p)	0.91; 0.86
$CH_3C_6H_4$ (o)	1.68; 1.64		

SERIES IV

In this list of experiments a variable aromatic amine was used in place of aniline as shown in the equation accompanying Table IV. The substituted diphenyl urea obtained by the reaction was washed with 50 c. c. of ether and the solubility correction added as in the previous cases.

TABLE IV

$$C_6H_5NHCOOC_2H_5 + RNH_2 = C_2H_5OH + C_6H_5NHCONHR$$

0.02 mole of components. Temp., 175°. Time, 3 hours.

R	Grams of disubstituted urea	R	Grams of disubstituted urea
C_6H_5	1.46; 1.46	$CH_3C_6H_4$ (o)	1.39; 1.39
ClC_6H_4 (o)	0.54; 0.53	$CH_3C_6H_4$ (m)	1.41; 1.39
ClC_6H_4 (m)	0.58; 0.58	$CH_3C_6H_4$ (p)	1.64; 1.68
ClC_6H_4 (p)	0.95; 0.98	$CH_3OC_6H_4$ (o)	1.63; 1.61
BrC_6H_4 (p)	1.07; 1.01	$CH_3OC_6H_4$ (p)	2.29; 2.29
$NO_2C_6H_4$ (o)	0.00; 0.00	$C_2H_5OC_6H_4$ (o)	1.37; 1.34
$NO_2C_6H_4$ (m)	0.00; 0.00	$C_2H_5OC_6H_4$ (p)	2.49; 2.54
$NO_2C_6H_4$ (p)	0.00; 0.00		

DISCUSSION AND SUMMARY

In Series I it will be noticed that the normal paraffin radicals are in direct order, with the methyl group the most negative and the n-heptyl radical the most positive. This reaction can be interpreted as shown in the following formulas:

$$C_6H_5NHCO\ :O\ :CH_3 \qquad\qquad C_6H_5NHCO:\ O:\ C_7H_{15}$$

The tendency of the methyl group to attract electrons more than the heptyl radical causes a greater shift of electrons toward the methyl with a consequently easier replacement of the methyl grouping. It will also be noticed that the branching radicals are more positive than their straight chain isomers, isopropyl being slightly more positive than normal propyl and tertiary butyl decidedly more positive than normal butyl.

Any of the branching aliphatic radicals may of course be considered as derivatives of methane. Two conflicting ideas are to be found in the literature regarding the nature of the substituted methyl radical as indicated in the following formulas:

$$\begin{array}{l} R:\ H \\ \quad >C:— \\ R: \end{array} \qquad\qquad \begin{array}{l} R:\ H \\ \quad >C—: \\ R: \end{array}$$

If the two radicals R attract electrons some investigators have held that a general shift of electrons toward these radicals would occur making the entire grouping more negative as shown in the formula at the left. On the other hand the idea of symmetry has been suggested which would lead to the electronic distribution indicated at the right, producing a relatively more positive radical. Our experiments support the symmetrical arrangement.

Table II shows that all of the aromatic radicals have a greater attraction for electrons than do any of the paraffin radicals, since they are much more readily replaced. In Series III the variable radical is farther removed from

the part of the molecule which undergoes change during the reaction and the effect of each group is not so apparent; also the tables of data show that the same order of radicals is not obtained. Consideration of Tables I, II and IV show the following order for the relative strength of the negative charge on the radicals studied.

o-$NO_2C_6H_4$ > m-$NO_2C_6H_4$ > o-ClC_6H_4 > p-ClC_6H_4 > p-$NO_2C_6H_4$ > C_6H_5 > o-$CH_3OC_6H_4$ > m-$CH_3C_6H_4$ > o-$CH_3C_6H_4$ > p-$CH_3C_6H_4$ > p-$CH_3OC_6H_4$ > CH_3 > C_2H_5 > n-C_3H_7 > iso-C_3H_7 > n-C_4H_9 > n-C_5H_{11} > iso-C_4H_9 > sec-C_4H_9 > n-C_7H_{15} > tert-C_4H_9

This line of investigation will be continued and other data will be presented later.

A Study of the Mechanism of the Effect of Chlorine on the Biochemical Oxygen Demand

FRANK T. CRAIN and SELMA GOTTLIEB, University of Kansas, Lawrence, Kan.

Although the biochemical oxygen demand test is accepted as a measure of the strength of sewage or wastes, disposal-plant efficiency, or stream pollution, it is doubted by workers well versed in the field that it should be accepted without question when complicating factors are introduced, as through the use of chemicals in sewage treatment, by which the normal fauna and flora in the sample are disturbed, changed or eliminated. It is therefore doubted that the B. O. D. test can be unquestionably depended upon to measure the efficiency of chlorine as a stabilizing agent for sewage, and it has been claimed that reductions of B. O. D. in five-day incubations at 20° C. are only temporary.

The biochemical oxygen demand of a sewage is the oxygen in parts per million required during stabilization of its decomposable organic matter by aerobic bacterial action. Complete stabilization requires a very long time, extending over a period of more than 100 days at 20° C., but since such long periods are impracticable a much shorter period of incubation is used. The dilution method is recommended. This, with incubation of the subsamples at 20° C. for five days, involves the addition of an excess of dissolved oxygen by suitable dilution with water of known content of dissolved oxygen. The dissolved oxygen is determined before and after incubation and the depletion is multiplied by the dilution factor to give the B. O. D. in p. p. m. of oxygen used.

The efficiency of a substance as a stabilizing agent, or the efficiency of a method of treatment for bringing about stabilization, can be estimated by determining the B. O. D. of a sample of the untreated sewage, and that of a sample of some of the same sewage which has been treated with the chemical or subjected to the method of treatment. The difference between these two B. O. D.'s is taken as the reduction brought about by the substance or by the method of treatment.

The introduction of chlorine is a widely advocated method of sewage treatment. Chlorine is a bactericidal agent with pronounced oxidizing properties and has been applied as an auxiliary to biological treatment and as a partial stabilizing agent for raw sewage. Its suggested use as such dates back to 1859 when Hofman and Frankland proposed to make chlorine gas aboard a steamer on the River Thames and discharge the gas into the river. The British Patent Office issued patents relating to the use of chorine gas on sewage as early as 1860. The cheaper chlorine, brought about by developments in chemical manufacture during the World War, has made the use of liquid chlorine the most common method of application.

A review of the literature on the reduction of B. O. D. of sewage or sewage effluents by chlorination reveals an apparently renewed interest and much investigational work on the problem since about 1926. Only a brief review of the field is presented in table I. These examples would indicate that chlorine materially decreases the B. O. D., retards the rate of bacterial reproduction

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effectively for a considerable period and therefore nullifies to a marked extent the effects of age, temperature and strength. Its ability is not restricted to its power as a direct oxidizer since a given amount will reduce the five-day B.O.D. several times its direct oxidizing power as calculated from potential oxidation by chlorination. There has been debate as to whether this reduction is absolute, or merely a slowing down of the rate of oxygen consumption, or is due to the bactericidal activity of the chlorine with consequent low B.O.D. results if the test portions are not properly reseeded with bacteria. These and other questions are of theoretical and practical interest. It is presumably possible that with more knowledge the amounts of chlorine applied could be reduced, the construction of dosing devices and detention tanks altered and different points of application utilized which would be more effective and more practical.

TABLE I

PLACE.	Type of sewage.	Dosage in p.p.m.	Percent B. O. D. reduction.
Harvard University (1)	Raw	....	33
Schenectady, N. Y. (2)	Raw	4–6	11–43
Indianapolis (3)	Raw	According to demand.	35
Indianapolis	Raw	According to demand.	15–20
Collinswood, N. J.	Raw	5.5	11
China (4)	Settled	8.8	40
Dallas, Tex. (5)	Imhoff effluent	Minor	10
Dallas, Tex.	Imhoff effluent	To insure residual.	45–62
Allentown, Pa. (6)	Imhoff effluent	4.9	12.6
Huntington, N. Y. (7)	Effluents from treatment plants of various sorts.	6.5-12	33
China		2	40
Houston, Tex.		2	28
Columbus, Ohio (8)		2.1	41.5
Coney Island, Mich. (9)		7.4	25–40

(1) Pearse, L., et al.: Chlorination in Sewage Treatment. Report of the Committee on Sewage Disposal, Public Health Engineering Section, American Public Health Association, New York, 1934, 51 pp.
(2) Cohn, M. W.: Engineering News-Record, 96:945-948, June 10, 1926.
(3) Calvert, C. K.: Industrial and Engineering Chemistry, 24:92-94, 1932.
(4) Gaunt, P., and Abbott, W. E.: J. Soc. Chem. Ind., 45:325, Sept. 10, 1926.
(5) Enslow, L. H.: Public Health Reports, 42:1623-1642, June 17, 1927.
(6) Krum, H. J.: Sewage Works Journal, 3:647-655, 1931.
(7) Tiedeman, W. D.: Engineering News-Record, 98:944-948, June 9, 1927.
(8) Lacy, I. O.: Sewage Works Journal, 3:636-646, 1931.
(9) Zack, S. J.: Sewage Works Journal, 5:471, May, 1933.
(10) Rudolfs, W., and Ziemba, J. V.: Journal of Bacteriology, 27:419-442, April, 1934.

There may be three general reactions in the mechanism of chlorination. First, the chlorine combines with the existing oxidizable materials to form compounds whose germicidal properties are negligible. Second, a chloro-substitution reaction occurs, resulting in the formation of chloro-compounds (chloro-amino acids, other chloro-organic acids, chloramines, etc., which may or may not be possessed of toxic properties. These chloro-compounds fix or loosely bind the chlorine. Third, with short contact periods, the chlorine may react directly with the bacteria. As the contact period is increased, bacterial reductions are brought about by chloro-products as well as by the primary

chlorine. When the chlorine demand is completely satisfied, bacterial reduction takes place rapidly.

THE GENERAL PLAN OF THE EXPERIMENT

To check previous findings, five-day B.O.D. reductions due to chlorine treatment were determined on settled sewage, and to learn more in regard to the permanency of the reductions, twenty-day B.O.D.'s were run.

To determine whether B.O.D. reductions are caused by disturbance or killing of normal fauna and flora by the changing of bacterial food by chlorine, B.O.D.'s of unchlorinated and of chlorinated raw sewage, autoclaved sewage and nutrient broth were run, the presence of sufficient organisms being assured by use of seeded dilution water.

To determine the effect when no primary chlorine was present in the subsamples, yet making sure that the chlorine demand of the sewage had been satisfied, B.O.D.'s were run in which the residual chlorine was destroyed just before dilution.

From the data obtained (table 2) it is concluded that chlorine stabilizes sewage materially as shown by five-day B.O.D. tests. Since the data show that the average degree of stabilization in twenty-day B.O.D. tests is of about the same order, it is concluded both, (1) that the B.O.D. reduction by chlorine is not merely temporary and (2) that the B.O.D. test, when properly carried out, is suitable for measuring the amount of reduction.

TABLE II

SUMMARY OF RESULTS

Incubation period five days except where otherwise indicated

KIND OF SEWAGE.	Number of samples.	Percent B. O. D. reduction.
Raw sewage, not reseeded	12	19.7
Same as above, 20 days	6	18.8
Raw sewage, parallel samples:		
Reseeded	3	13.3
Not reseeded	3	16.2
Autoclaved sewage (reseeded)	6	17.2
Nutrient broth (reseeded)	7	11.0

Chlorine treatment in the absence of sewage organisms materially stabilized autoclaved sewage and nutrient broth and it is therefore concluded that chlorine acts by rendering organic food substances useless or perhaps toxic to sewage bacteria. From the data showing that chlorine stabilizes unreseeded sewage to a greater extent than it does reseeded sewage it is concluded that chlorine also acts directly upon the organisms. Therefore it may be inferred that chlorine affects bacteria and their food simultaneously.

The B.O.D. reduction was practically the same when the 0.5 p.p.m. of residual chlorine was allowed to remain in the sewage and when the residual was destroyed before dilution of the sample. It is therefore concluded that the effect of this residual is negligible as compared with the effect of the

absorbed chlorine. On samples which were chlorinated and not reseeded, the B.O.D.'s were reduced 11.6 percent when the chlorine was neutralized with sodium thiosulphate and 12.7 percent when it was not neutralized. On chlorinated and reseeded samples, the B.O.D. reductions were 21.7 percent and 18.6 percent, respectively, under the same conditions.

Rudolfs and Ziemba (10) found that contact of sewage with enough chlorine to produce a residual after ten minutes reduced the number of bacteria 99.8 percent. The results show that the B.O.D. decrease averaged only 18.4 percent when the sewage was not reseeded. No bacterial counts were made in this work, and hence it can only be assumed that reproduction by the bacteria remaining after chlorination was rapid enough to account for the discrepancy between the B.O.D. reductions found and the reduction in bacterial population to be expected from the work of Rudolfs and Ziemba. Further work should be undertaken to correlate the effect of chlorination on bacterial population and on biochemical oxygen demand, using the same sample of sewage.

Studies on Two Kansas Oil Wells: Mineralogy of the Formations and Chemical Nature of the Waters Encountered

L. A. CRUM, K. E. R. C., Wichita, Kan., and SELMA GOTTLIEB, Water Laboratory, University of Kansas

The two wells represented in this report were drilled last summer in central Kansas on the divide between the Smoky Hill river to the north in Ellsworth county and the Arkansas river to the south in Rice county. The topography of the vicinity is rough, rolling prairie. Rocks exposed on the surface near the wells are of Cretaceous system, probably Dakota formation. Regionally, the location is on the prairie plains westward dipping monocline and on the east flank of the structural feature known as the Central Kansas uplift.

Porter-Deardorf Well No. 1 was drilled by Lario-Elwell et al. in the northeast corner of the northwest quarter of section 5, township 18, range 7 west, 1½ miles east of the town of Geneseo in Rice county. Drilling was commenced July 19, 1934, and completed September 15, 1934, to a total depth of 3,452 feet. Between July 28 and September 20, 1934, the same operators drilled Campbell Well No. 1 approximately 2¾ miles northwest of the Porter well in the southwest corner of section 20, township 17, range 7 west, Ellsworth county, to a total depth of 3,511 feet. Neither well was productive of oil or gas.

Both wells encountered several rock levels from which water was accumulated in the hole. Samples of water were saved by the Skelly Oil Co. and sent to the State Board of Health for examination. Several hundred samples of drill cuttings obtained from the Campbell No. 1 were studied microscopically, and an attempt has been made to determine the geological formations from which water samples were obtained in both wells. These conclusions are based on the best information available from a study of samples of drill cuttings and the drillers' logs of the two wells in comparison to other wells drilled and studied in Kansas.

Drilling of both wells started in rocks of the Cretaceous system, which were found to be predominantly red and yellow sand and dark shale. Permian red beds of the Cimarron group were found from approximately 260 to 650 feet. The Sumner group of the Permian system was characterized by salt, anhydrite, shale, thin limestone, and thin layers of red rock. The Chase group of the Permian system and all of the Pennsylvanian system consisted principally of limestone interbedded with thin shale and red rock with occasional sandy lime beds and chert. In the basal part of the Pennsylvanian system was found between 60 and 90 feet of conglomerate, probably the result of an erosional period.

Green shale was encountered in the Campbell No. 1, which may be classified in the Kinderhook (?) group of the Mississippian system. This horizon is not known to be present in the Porter-Deardorf well. Rocks which probably are of the Ordovician system were encountered in both wells at an approximate average depth of 3,255 and 3,280 feet. These consisted of lime, dolomite, green and gray shale, and sand. The "siliceous" lime encountered

TABLE I.—Porter-Deardorff well No. 1, NE cor. NW¼ 5-18-7W, Rice county, Kansas*

Depth.	Geological horizon from which water was produced.			Total solids.	Chlorides.	Sulfate.	Total hardness.	Alkalinity.
	System.	Group.	Member or local name.					
165-75	Cretaceous	Commanchean	Kiowa shale	303	43	43	258	246
220-40	Cretaceous	Commanchean	Cheyenne sand	973	358	210	376	266
1400-05	Permian	Chase	Florence flint	263,800	145,200	846	50,706	26
1995	Pennsylvanian	Wabaunsee		262,700	144,000	796	49,232	29
2590-95	Pennsylvanian	Shawnee		245,500	133,200	71	47,838	27
2735	Pennsylvanian	Douglas (?)		243,000	133,600	145	48,173	42
2925	Pennsylvanian	Lansing-Kansas City		207,500	116,000	76	40,067	44
2985-90	Pennsylvanian	Lansing-Kansas City		215,000	115,600	60	40,741	26
3400	Ordovician	Simpson	Sand	21,690	10,500	1,906	4,488	149
3441-44	Cambro-Ordovician	Arbuckle	"Siliceous" lime	20,300	9,850	1,710	3,767	76

*Analyses expressed in milligrams per liter.

TABLE II.—Campbell well No. 1, SW cor. 20-17-7W, Ellsworth county, Kansas*

Depth.	Geological horizon from which water was produced.			Total solids.	Chlorides.	Sulfate.	Total hardness.	Alkalinity.
	System.	Group.	Member or local name.					
65-70	Cretaceous	"Upper" Cretaceous	Dakota sand	517	41	82	274	322
205-20	Cretaceous	Commanchean	Cheyenne sand	731	134	161	279	248
300	Permian	Cimarron	Red Beds	1,909	570	519	721	150
1400	Permian	Chase	Florence flint	276,200	150,000	810	55,045	22
2600	Pennsylvanian	Shawnee	....	239,700	132,500	99	48,047	24
2705-15	Pennsylvanian	Douglas (?)	....	245,000	132,000	133	46,687	34
2855	Pennsylvanian	Lansing-Kansas City	....	212,800	115,000	86	39,931	20
2920	Pennsylvanian	Lansing-Kansas City	....	226,300	121,000	145	41,947	34
3410-25	Ordovician	Simpson	Sand	59,900	29,700	1,815	11,080	96
3475	Cambro-Ordovician	Arbuckle	"Siliceous" lime	28,300	14,050	1,690	4,985	115
3475-80	Cambro-Ordovician	....	"Siliceous" lime	21,110	10,300	1,756	3,913	61

*Analyses expressed in milligrams per liter.

at approximately 3,440 and 3,475 feet was a crystalline dolomite. This horizon may be correlative with part of the Arbuckle limestone of Oklahoma and with part of the Ordovician and Cambrian systems.

In tables I and II are tabulated summaries of the above findings together with an indication of the various depths at which water samples were taken, and results of chemical analysis of these waters. Up to a depth of around 300 feet the waters encountered were fresh, or relatively so. From about 1,400 to nearly 3,000 feet in both wells very highly mineralized waters were encountered, the dissolved mineral matter consisting chiefly of the chlorides of sodium, calcium and magnesium, accompanied by varying relatively minor amounts of the sulfates and bicarbonates of these metals. In comparison with these very strong brines showing a maximum of 150,000 milligrams of chloride per liter, ocean water averages around 20,000 milligrams of chloride per liter. At around 3,400 feet, a different type of water appeared in both wells. This type is lower in dissolved mineral matter, ranging from 9,850 to 29,700 milligrams of chloride per liter, and is also characterized by a larger content of sulfate than the stronger brines and by a distinct odor of hydrogen sulfide. Quantitative determinations of hydrogen sulfide were not attempted since it was not possible to make the necessary field tests.

This wide difference between the top and bottom waters with the top waters much the higher in dissolved mineral matter is corroborated by published analyses of similar waters in the El Dorado and Augusta, Kansas fields.*
Although most of the subsurface waters associated with oil-bearing formations carry appreciable quantities of mineral salts in solution, they may differ widely in composition in the various fields.

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* Identification of Oil-field Waters by Chemical Analysis. C. E. Reistle, Jr., Tech. Paper 404, Bureau of Mines (1927).

The Use of Activated Carbon in Water Purification

PAUL D. HANEY, University of Kansas, Lawrence, Kan.

One of the most difficult problems encountered in water purification is that of taste and odor control. The usual taste- and odor-producing substances in water are probably represented by organic matter in an incomplete state of decomposition. Unusual characteristics are often caused by industrial wastes, especially those containing phenol (1). In commenting on the problem of tastes and odors, John R. Baylis, an authority on water purification, has said, (2):

"The margin of safety against taste becomes narrower and narrower for some of our supplies now producing satisfactory water. The time is not far distant when steps must be taken to obtain a less polluted supply or there must be an improvement in purification methods."

The use of activated carbon as a means of eliminating tastes and odors has, in many cases, proved to be the needed improvement in purification. It has not been a cure-all by any means, but it has been, on the whole, very successful; and the interest in its use has been recent and widespread.

EARLY USE OF CARBON AS A PURIFYING AGENT (3)

There is no exact record of when charcoal began to be used as a purifying agent for water though there is evidence that it dates back prior to 1800. Cities began to distribute water in pipes through the streets to the inhabitants in the early part of the eighteenth century and the frequent use of home charcoal filters to improve the quality of the water followed shortly thereafter.

A number of large municipal carbon filters were built in England and in this country between 1852 and 1858. The first attempt at filtration through layers of sand and charcoal in this country was at Elizabeth, N. J., in 1852. Other towns where charcoal filters have been constructed are Marshalltown, Iowa, 1877; Keokuk, Iowa, 1878; and Hannibal, Mo., 1880.

It is at once evident from a study of water-purification literature that a real effort was made to use charcoal as a purifying agent for water.

Charcoal for small home filters was fairly successful, but the attempts to use it on a large scale gave rather poor results, for the charcoal beds were very short-lived; that is, they soon reached the point where they failed to adsorb impurities from the water. Engineers, realizing the limitations of the old charcoal units, left charcoal filter beds out of their plant designs and carbon, as a water purifier, dropped into discard for nearly forty years.

In 1852 when the first attempts were being made to use charcoal for municipal filters, and even in later years, the phenomenon of adsorption was not very well known or understood. No one realized that, though fresh charcoal was very effective in removing certain dissolved organic compounds from the water, it soon reached a condition where no more of the compounds could be adsorbed.

The prevailing idea probably was that the adsorbed material was changed to some inoffensive compound by the carbon. It is probable that some of the

adsorbed compounds do change after adsorption, but the change is not such but that the carbon will soon reach the point where it fails to remove all the objectionable compounds from highly polluted water.

Years ago no one knew how to prepare a carbon with higher adsorptive capacity. The carbon then used was just ordinary charcoal or bone char which we know is not very active; that is, it does not have a high adsorptive capacity. Tests made on the old charcoals show that such materials have adsorptive capacities which are only a small percent of the capacity of the highly activated carbons now on the market (3).

In charcoal resulting from the ordinary carbonizing process, only a very small percentage of the carbon atoms going to make up the charcoal are capable of adsorbing other substances to any great extent. This may be due to the type of primary carbon formed or to the carbon adsorbing compounds released from the carbonaceous material as it is heated, or both.

Active carbon is believed to be formed whenever carbonaceous substances are carbonized in closed vessels at low temperatures; but because of its activity, it is believed to become saturated with hydrocarbons liberated during the process of carbonization (4). The process of removing the adsorbed hydrocarbons which mask the carbon surfaces is part of the process known as activation.

Chaney (4) and coworkers have found that when the active carbon adsorbs hydrocarbons these hydrocarbons are stabilized to a remarkable extent, and are held in the adsorbed state under conditions of temperature and pressure at which they would otherwise be volatilized or decomposed. As evidence for this belief Chaney has pointed out that quantities of a hydrocarbon closely resembling anthracene, the boiling point of which is approximately 350° C, have been isolated from cedar charcoal which had been previously calcined at 850° C.

This stabilized complex of hydrocarbons adsorbed on a base of active carbon is the product which is defined as primary carbon (4). It is termed primary carbon because it is the original product occurring in the low temperature carbonization of carbonaceous materials.

The hydrocarbon constituents of the adsorption complex appear to be slightly less resistant to oxidation than the active carbon; and by the proper adjustment of temperature and concentration of the oxidizing agent, the adsorbed hydrocarbons may be removed. Oxidizing agents used to the greatest extent are air and superheated steam. Carbon dioxide and chlorine have also been used, but only to a limited extent. This operation requires careful control; but when properly carried out, a good quality of activated carbon results. In addition to this operation the carbon's physical structure is enormously altered by expanding or puffing the carbon, much as wheat or rice is puffed. This provides a porous structure which is essential to high adsorptive capacity. These two operations constitute the process of activation (4) (5).

The activity of a particular carbon is based on the weight of a substance adsorbed by one gram of carbon. This activity, of course, varies with different substances and is given in terms of phenol activity, iodine activity and so on. A good grade of activated carbon should meet the following test: Thirty-five parts per million of carbon should reduce the phenol in a solution containing 0.1 part per million phenol to .01 part per million when stirred for two hours at

20° to 25° C. (7). The adsorption of phenol activated carbon follows the Freundlich adsorption equation very closely (2).

There is considerable loss in converting any carbonaceous material to primary carbon except for material low in volatile matter such as anthracite coal. The loss in producing a primary carbon is roughly proportional to the volatile matter in the raw material. After primary carbon has been produced, there is further loss in activating. It has been shown (4) that this loss may be as high as approximately 80 percent of the weight of the primary carbon if activation is carried on for longer than one hour although a more active material results from longer activation.

Some figures on the effect of activation on adsorptive power (4):

Carbon	$MgCCl_4$ adsorbed per gram of carbon
Primary coconut	47
Activated coconut	630
Primary ironwood	30
Activated ironwood	1160
Primary lignite	30
Activated lignite	640
Extremely activated lignite	2715

One of the largest plants for the production of activated carbon is located at Marshall, Tex. The product is known as "Hydrodarco," and is made from lignite. Two plants manufacturing carbon known as "Nuchar" are located at Tyrone, Pa., and Piedmont, W. Va. Nuchar is made from waste products from paper mills.

Careful research into the possibilities of using activated carbon in water purification work in this country was undertaken by John R. Baylis (2) at the Chicago Experimental Filtration Plant in 1928. Other studies were made at the Cleveland Baldwin filtration plant about the same time (1). Still other early experimenters were Norcom and Dodd at Chester, Pa. (7), and Behrman and Crane (8) at Chicago, Ill.

The early experiments in water treatment by activated carbon were along the lines of gravity and pressure filter beds of carbon in the granular form. Although the effectiveness of such treatment was at once apparent to the early investigators, not many municipal installations of this type have been made because of the high cost of equipment. It was found very difficult to incorporate this treatment into already existing plants (1). Furthermore, many plants which are troubled with taste and odors are troubled only a part of the year, and the use of special carbon beds would be very expensive for these plants (9). There was not much enthusiasm at first for the use of activated carbon, but in 1930 tests at the South Pittsburgh, Pa. (1) water-softening plant showed the success of using carbon in a new form—the powdered form. This was a marked step forward, as it was found that the powdered form could be fed into the water by simple inexpensive apparatus, and was very effective even at great dilution. The expensive contact beds were thus eliminated and the use of carbon for taste and odor control became feasible for small plants.

Since 1931 the acceptance of activated carbon as a useful material in waterworks practice has been very rapid. Before 1931 only four municipal water supplies had been treated by activated carbon, whereas it is now being used in nearly 700 water-purification plants in the United States and Canada (5).

Activated carbon is now being applied at almost every conceivable point in plant processing. A number of operators apply it to the raw water as it enters the plant for processing. Others apply it either in conjunction with the coagulant or at the same point as the coagulant. Still others apply it as it enters the sedimentation basins or as it leaves the basins and enters the filters. It is sometimes applied directly to the filters. In a few plants a split feed is used, a part of the carbon being applied to the coagulating basin and the balance upon the filters. It is generally recommended, however, that the application be made to the coagulation effluent if possible (1) (9).

Unfortunately, almost every plant now applying carbon was designed with no thought of ever using it as a means of taste and odor control. Often plant construction features are such as to require feeding at some particular point even though it is not the best one.

One point which cannot be overemphasized is that, other things being equal, the best point of application is that point where the carbon can be mixed as thoroughly as possible with the water to be treated.

The mechanics of application are comparatively simple, and three ways of feeding are as follows: (10)

(1) Dry feed—using a dry-feed machine equipped with water ejector. This is considered the best method.

(2) "Solution" feed—For emergency use. Outfit consists of an ordinary barrel for holding the carbon-water mixture and a suitable control valve.

(3) Mixed with chemicals. Mixed with chemicals and fed by chemical machine.

COST

Five to twenty pounds of carbon per million gallons has been reported as the satisfactory dosage by 81 percent of the plants using it. At an average cost of six cents per pound, the use of carbon costs between 30 cents and $1.20 per million gallons (10).

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The Effects of Synthetic Atmospheres of Nitrous Oxid and Oxygen Upon Animal Life

J. WILLARD HERSHEY, L. A. ENBERG, and ARTHUR DEVOR, McPherson College, McPherson, Kan.

About twelve years ago experiments on the effects of synthetic atmospheres on animal life were begun at McPherson College. Many experiments (1, 2) with various types of animals have shown that animals live but a short time in oxygen alone. This fact indicates that a diluent of some kind is necessary. In the air nitrogen and the rare gases act in that capacity. As a consequence experiments have been conducted using inactive gases as substituents for the inert part of air (3, 4, 5). Just recently work was begun on another series using relatively active gases as a diluent of oxygen in synthetic atmospheres (6). This paper reports the progress of the second in that series, namely the effects of the use of nitrous oxid and oxygen in various mixtures. Nitrous oxid was chosen for this series of experiments since mixtures of it with oxygen are rather commonly used as an anesthetic.

Anesthesia has been defined by F. P. deCaux (7) as "the name given to a state of unconsciousness associated with loss of, not only pain sensation, but also the normal reflexes to painful stimuli." Thus nitrous oxid and oxygen in certain percentages form a mixture which is an anesthetic pure and simple.

Nitrous oxid was first made by Stephen Hales, as shown on page 224 of his Statical Essays, published in 1738. That he did not recognize the gas is certain. Joseph Priestley, in 1772, repeated the experiments of Doctor Hales and added to them. He also published the results, but quite obviously did not recognize the gas (8). Priestley was the first to note the anesthetic effect of the gas on animal life (white mice).

It remained for Sir Humphrey Davy to notice the effects of the gas on human beings and to give it the name laughing gas. In a note in 1794 he writes after inhaling sixteen quarts of the gas: "I danced about the laboratory as a madman." In 1799 L. Edgeworth remarked after breathing the gas, "I burst into a violent fit of laughter, and capered about the room without having the power of restraining myself." Davy determined the composition of the gas in 1800.

Oxygen, the vital element for respiration, was really discovered in 1773 by Scheele, a Swede, although by priority of publication in 1774, Priestley is usually called the discoverer of oxygen.

According to Wieland (9) the narcotic effects of nitrous oxid are associated with a deranged oxygen absorption or utilization. Leake and Hertzman (10) also hold that anesthesia under nitrous oxid and oxygen cannot be maintained without annoxemia. Acidosis may also be a reason for the effects of nitrous oxid as explained by Koehler (11). In experiments with anesthesias of dogs, Greene and Curry (12) found that anesthesia was not possible with inhalation percentages of oxygen greater than 11.5 percent. Less than 3.6 percent was sufficient to support life. In checking the concentration of nitrous oxid in the blood during these anesthesia it was found by Greene and his collabora-

tors (13) that it varies from 19 to 26 volume percentage. The degree of anesthesia depends, however, upon the concentration of oxygen.

Anesthesia did not occur until the percent of oxygen was less than 7 in nitrous oxid and oxygen mixtures for rats, mice, cats, rabbits, guinea pigs and dogs (14). According to Henderson and Lucus (15) nitrous oxid produces anesthesia in animals only when the animals are suffering from lack of oxygen as well as the presence of nitrous oxid dissolved in the blood and tissues—a difference from other anesthesia. Webster (16) reports an increase in the number but not the size of the red blood cells. From Desmarest and Loscomles (17) we find that after the use of ether and chloroform for general anesthesia, a pronounced cholemia appears which requires 5 to 6 days to disappear, whereas a mixture of nitrous oxid and oxygen never produces cholemia.

The apparatus and manipulation were both rather simple. The gases used were of the highest purity obtainable. (Nitrous oxid 99.5 percent pure, the impurity being nitrogen; oxygen 99.7 percent pure, the impurity being just air.) Literature suggests that in the use of nitrous oxid contaminated with a slight amount of nitrogen that the cylinder be used in a horizontal position. This the company, also, very specifically advised being done. In our experiments we have found that under a very slight flow of gas from the cylinder the variation in flow would sometimes be as high as 300 percent. Upon placing the cylinder in a vertical position the flow became more nearly constant for rates of flow as small as 5 c. c. per minute. For the regulation of the nitrous oxid flow a standard type regulator was used, its outlet being connected to a 500 c. c. reservoir. The pressure was reduced from the large cylinder to a constant subpressure in the reservoir, the subpressure varying from 20 mm. mercury to as high as 400 mm., depending upon the rate of flow desired through a small jet. This small jet of approximately 0.002 mm. radius was placed in the outlet of the reservoir. For the regulation of the oxygen a needle valve was used. This permitted regulation of the nitrous oxid first to a constant flow and then by means of the precise adjustment obtainable by the needle valve on the oxygen tank to set up the correct proportion desired for the mixture. The type of regulation used on the nitrous oxid was found to be quite constant as it usually would not vary over 0.25 percent for twenty-four hours. The oxygen regulation was checked several times per day in order to insure the maintenance of the desired proportion. The proportion was secured by passing the gases through bubble tubes containing pure water, thus simply by counting the number of bubbles per minute the desired percentage could be obtained. The actual rate of flow of the mixture was approximately 7.5 c. c. per minute for each mouse. In most of the experiments two mice or more have been subjected to the same mixture through the use of double outlet tubes from the gas regulation control device and drying tubes. The mice were confined in glass bottles having the inlet for the synthetic mixture at the base. This inlet was so located because of the greater density of the mixture than air. Food and fresh water were kept before the mice constantly. The confinement bottles were sterilized after the conclusion of each experiment and fresh excelsior, food, and water were inserted. The bottles were always filled with the desired mixture before the insertion of the animal. This mixture was checked by analysis and during the run of the experiments samples

of the inhalent gas were analyzed to check the constancy of the input mixture. Analyses were also made on the expired gas from the outlet. During the experiments the respiration, conduct, general appearance, and behavior of the animals were observed. The temperature of the mixture within the confinement chamber was also checked. Many times upon the death of an animal dissection was made, and the condition of the heart, lungs, and blood was observed.

The gas analysis apparatus was of the conventional Hempel type. The absorbent mixture for carbon dioxide was potassium hydroxide of specific gravity 1.55 as recommended by Dennis (18). The absorbent mixture for oxygen was alkaline pyrogallol contained in a Hempel double absorption pipette. The nitrous oxid was determined by difference. Due to the physical solubility of nitrous oxid in alkaline solution such as potassium hydroxide, a correction had to be made. This was done by taking known samples and making test analyses. The error here is relatively small, being well within the limits of accuracy of the experiments as a whole.

The life periods of white mice in the various mixtures that were used in these experiments are as follows:

Percentage Mixtures.		Limits.	Number of animals.
100 percent N_2O		60 to 150 secs.	3
95 percent N_2O	5 percent O_2	3 to 5 mins.	3
92.5 percent N_2O	7.5 percent O	9.3 mins.	1
90 percent N_2O	10 percent O_2	10.5 to 13 5 days	8
75 percent N_2O	25 percent O_2	2 to 9.5 days	9
50 percent N_2O	50 percent O_2	3.3 to 10.3 days	9
25 percent N_2O	75 percent O_2	4 to 10 days	4
10 percent N_2O	90 percent O_2	4 to 12 days	4
5 percent N_2O	95 percent O_2	5 to 14 days	4

The lungs of dissected mice which had died in pure laughing gas were always very white in color, indicating, in part at least, that lack of oxygen is a contributing factor in these deaths. The same is true of animals dying in anesthetic mixtures with oxygen, *i.e.*, below 7.5 percent oxygen. In nearly every case of dissection in those regions of low percentage of oxygen the heart was found still to be beating. This conditioned a paralysis of the respiratory center, which is perhaps due to the nitrous oxid. The deep sleep and the deep breathing into which the animals fell upon introduction to anesthetic mixtures is very much like the characteristics reported for human anesthesias. As the animals approached respiratory cessation the breathing became spasmodic and irregular. This has been the case in every experiment in this series. In the low percentage oxygen ranges toward the end of respiration there commenced a period in which the expiration was much more prolonged than inspiration. According to Luis Hevia (19) these reactions indicate lack of suffi-

cient oxygen. He says (speaking of anesthesias), "If this condition arises and is not controlled, it may result in a total suspension of respiration." This is exactly what happened when the above conditions were observed.

In one case in which a mouse had ceased breathing in a mixture of 95 percent nitrous oxid 5 percent oxygen, after dissection the heart beat for 41 minutes at the rate of 176 beats per minute. In another case of the same mixture an attempt at revival with pure oxygen failed, and upon dissection it was discovered that the heart had also stopped.

In one case in a series of 90 percent nitrous oxid, 10 percent oxygen, two mice used were very young. Two similar mice of the same age were kept out in the open air for comparison purposes as to rate of growth. It was found that the mice living in the synthetic mixtures grew but very little in the ten or more days in which they were confined while those on the outside became practically full-sized in the same period of time. The difference in health was also very noticeable. The confined mice were very weak.

In the mixture of 75 percent nitrous oxid, 25 percent oxygen, an exhilarating effect was noticeable during the first day or so. The mice became quite lively in action but seemed to have no control of those actions. A sort of stupefaction was apparent and the conduct of the animals resembled nothing so much as that of an intoxicated person. Dissection showed practically normal lung tissues.

As may be apparent from the longevity figures which are given above no anesthetic effect was noticeable in mixtures containing 10 percent oxygen and higher. In other mixtures, however, weakness and irregular breathing were observed.

With 50-50 mixture and above in percent of oxygen weakness is again seen. Dissections of animals dying show a quite red lung tissue which is obviously a sign of hemorrhage. This condition is no doubt due to the high oxygen content of the mixture.

With a synthetic atmosphere consisting of 79 percent nitrogen and 21 percent nitrous oxid, an experiment was started—

(1) With a male mouse at 1:57 p.m.:

Time p. m.	Respiration	Remarks
1:57	186	———
2:15	326	———
2:30	275	———
2:45	252	———
3:00	384	Began to struggle
3:13	...	Death struggle
3:14	None	Dead, total time 77 minutes

(2) With a female mouse at 4:02 p.m.:

Time p. m.	Respiration	Remarks
4:02	182	———
4:15	326	———
4:30	316	———
4:45	288	———
5:00	254	———
5:13	78	———
5:15	24	———
5:18	...	Death struggle
5:21	None	Dead, total time 79 minutes

The bottle in which the mice were kept was filled with the synthetic mixture before the experiment was begun. The figures as stated are exact; the mice were watched constantly during the experiments.

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Base Exchange in Soils*

ALFRED T. PERKINS and H. H. KING, Kansas Agricultural Experiment Station, Manhattan, Kan.

There have been many statements in the literature that base exchange phenomena in soils is largely associated with the finer portions. Among others Kelley and Brown (2) give data to substantiate this statement. The consensus of opinion seems to be that base exchange is an adsorption phenomena and is associated with the alumino silicate complexes of the soil. Way (5), among others, indicated these facts and showed that base exchange is a double decomposition reaction. It is also commonly considered that in a group of soils the base exchange capacity varies with the SiO_2-R_2O_3 ratio, especially of the colloid fraction (3). The work presented in this paper is an attempt to determine more definitely the actual facts of the base exchange in soils including its relation between particle size, SiO_2-R_2-O_3 ratio, and specific gravity of soil separates and fractions.

The data presented herein represent only a part of the work originally planned. The destruction of our chemistry building by fire causing the loss of soil separates and fractions before complete data had been collected on them, as well as the residual soil masses from which additional separates and fractions were to be obtained prevented the completion of the work.

SOILS USED

Three soils, differing somewhat in origin and geological development, were selected for this study. The soils chosen were those designated Oswego, Crawford, and Derby. A portion of each soil was saturated with N/20 HCl. Other portions of the soils were saturated with calcium and ammonium by leaching separate samples with neutral normal $CaCl_2$ and NH_4Cl respectively. The exchange reaction was considered to be complete when the leachings of the HCl and NH_4Cl treated soils gave no test for calcium. Calcium is commonly considered to be one of the hardest cations to replace in a soil as it has a high energy of adsorption. It seemed logical that when the NH_4 ion had completely replaced the absorbed calcium in the NH_4 treated soil similar treatment with calcium would replace the other ions in the Ca treated soil. The general system of treatment was to place 2,000 grams of soil in a beaker and add to it several liters of the solution with which it was to be treated. The soil was then thoroughly stirred, worked with the hand and then filtered by suction on a Büchner funnel. A similar quantity of solution was then run through the soil on the funnel. The soil was then returned to the beaker, fresh solution was added and the process repeated until test showed freedom from the calcium ion or a definite number of treatments had been made. By returning the soil mass to the beaker and working it with the hand all retention of ions as a result of channeling was prevented.

The result of treating the soils with the various cations was to give nine soil varieties of different properties. The three hydrogen soils would simulate very poor acid soils; the three calcium soils would be neutral soils, and the

* Contribution No. 209, Department of Chemistry, Kansas State College, Manhattan, Kan.

three ammonia soils would be well deflocculated and slightly alkaline. Of the untreated soils the Oswego and Crawford might be considered to be somewhat poor to fair and acid in nature. The Derby soil would be considered a moderately fertile neutral soil. The designation used to indicate these soils is Oswego H, Oswego Ca, and Oswego NH_4 to represent the Oswego soil saturated with H, Ca, or NH_4. The Derby and Crawford soils had the similar designations.

SOIL SEPARATES

The nine soil varieties resulting from saturating the 3 soils with various cations were further subdivided into six separates by sedimentation. The method followed in each case was to thoroughly work by hand the soil, containing enough water to make a thick mud, in order to break up the aggregates. The soil was then uniformly suspended in a large hydrometer jar and allowed to settle 6⅔ minutes for each 24 inches of depth of suspension when the upper suspension was syphoned off. The soil particles which had settled out were then restirred and again sedimentation was allowed to continue for 6⅔ minutes. The process was continued until the supernatant suspension was almost clear. Several times during the course of the separation the soil mass was worked with the hands to break up soil aggregates. Microscopic examinations of the coarse portion that would settle out were made to assure that no aggregates remained unbroken. Care was exercised to have the soil suspension sufficiently dilute that the mass of particles would not upset the normal speed of sedimentation. The water used in sedimentation was adjusted to 25°C.

After the coarse particles that would settle out in 6⅔ minutes had been separated, other separations were made. The final results were to give six separate portions from each soil variety. The coarser particles would settle through 24 inches of water in 6⅔ minutes, the next portion would remain suspended 6⅔ minutes, but would settle out in 40 minutes. The other portions would remain suspended 40 minutes, 4 hours, 24 hours, 6 days and would settle in 4 hours, 24 hours, 6 days, and in more than 6 days. We now had 54 portions of soil separates. While the latter separations were in process of being made they were lost due to the destruction of the chemistry building, so no data is available on them. The designation adopted for these separates is made evident by referring to Table I. For the proper freeing of each separate from the finer particles sedimentation must be carried out about 30 times.

SOIL FRACTIONS

It was further planned to divide each of the 54 soil separates into 6 fractions according to the specific gravity of the particles. This was to be accomplished by adjusting the specific gravity of bromoform carbon tetrachloride solutions by altering the percentage composition of the solution, making a suspension of the soil separates and then centrifuging. The particles were separated into fractions that would float on a solution of specific gravity 2.0; sink in a specific gravity 2.0, but float on 2.4; sink in 2.4, but float on 2.5; sink in 2.5, but float on 2.6; sink in 2.6, but float on 2.7 and those that would sink in a solution of a specific gravity of 2.7. The designation of these particles is made evident by saying that Oswego, Ca-3, (2.4-2.5) indicates a fraction obtained from Oswego soil suspending in 24-inch column of water 40 minutes,

but settling in 4 hours, having a specific gravity between 2.4 and 2.5. Part of these fractionations were made.

METHODS OF ANALYSIS

The soil separates and fractions were analyzed for SiO_2 content and R_2O_3 content, according to the methods given in Mahin (4), and for base exchange capacity according to the method given by Hissink (1), namely, treating 5 grams of soil material with neutral normal NH_4Cl until exchange is complete and then washing the excess NH_4Cl out with water or 80 percent alcohol and determining the adsorbed NH_4 by liberating it with MgO and distilling it over into standard acid.

During the course of the work it was evident that the finer particles on separation and drying tended to puddle or cake. It has since been discovered that this tendency could be overcome by washing the water from the separates with 95 percent alcohol and then washing the alcohol from the separates with anhydrous ether. Suction and a Büchner funnel are of great assistance in the washing, and probably absolute alcohol would serve better than 95 percent alcohol.

The average size of the particles in the separates was determined by measuring them under the microscope with the help of an ocular micrometer. Each average size was determined by measuring over 250 soil particles.

The results of the chemical analyses, base exchange determinations, and microscopic measurements are given in Tables II and III for the soil separates and fractions, respectively.

DISCUSSION

Reference to Table II indicates that by increasing six-fold the time of sedimentation, particles of approximately one half the average diameter were obtained. For particles of the size obtained in this work this is in general agreement with Stokes' law. The relative size of the particles as separated agrees with this law, so there is little doubt as to the value of sedimentation as a means of separating soil particles of definite size.

Table II shows that the effect of different cations adsorbed by the soil is negligible in separating the coarser soil particles by sedimentation. Such differences in size as occur could readily be caused by the slight variations in the method used for the different soil varieties. However, it is our opinion that adsorbed base will affect size of particles settling out in a given time when the smaller particles are dealt with. In the long, tedious process involved in this way of obtaining the colloidal fraction it is probable that repeated treatments with the cation involved would be necessary to maintain complete soil saturation.

In general it will be noted that for the coarser fractions of the soil that as degree of fineness increases the percentage of SiO_2 decreases while the R_2O_3 percentage increases. This means that for the soils worked with as degree of fineness increases the SiO_2/R_2O_3 ratio decreases. This is in accord with the results obtained by certain other investigators. With the increasing degree of fineness the base exchange capacity increases. This is in accord with the general opinion with soil scientists. However, this increasing base exchange capacity accompanied with a decreasing SiO_2/R_2O_3 ratio is not in accord with

the general idea. This apparent variation is not a contradiction, however, as we have worked on the coarser soil portions, and the general opinion of soil investigators in regard to the relation between R_2O_3/SiO_2 ratio and base exchange is based on studies of the colloidal fraction of the soil.

The data in Table IV has been assembled to show the relation between particle size of the coarser particles and base exchange capacity of the separates. The figures given are the averages for the nine soil varieties given in Table II. The interesting point is that when working with the coarser soil particles as the degree of fineness increases the base exchange capacity increases, but only about one fourth as fast as the surface increases. This is emphasized by the statement that the finer fractions have less base exchange capacity per unit surface than the coarser fractions.

In Table II data are given for the separates from nine soil varieties which have been fractionated according to specific gravity. The datum shows quite clearly that the soil particles between a specific gravity of 2.6 and 2.7 are high in silica and low in R_2O_3. From the data available it is seen that in general there is a tendency for the base exchange capacity to decrease as the specific gravity increases. This is in line with the generally accepted theory that the base exchange phenomena is associated with the alumino-silicate complexes, which are of light specific gravity. There is some datum to indicate that there is a mineral of heavy specific gravity that is active in base exchange.

A partial repetition of the work herein reported is in progress and it is hoped in the not too distant future to report the repeated work and its extension into the colloidal phase.

CONCLUSIONS

From the three soils used in this work and divided by arbitrary methods into several separates and fractions the following conclusions may be drawn for the particles coarser than 0.0040 mm. in diameter.

1. In the coarser soil particles adsorbed base does not affect the size of particle as separated by sedimentation and according to specific gravity.

2. When dealing with the coarser soil particles as the degree of fineness increases the percentage of SiO_2 decreases and the percentage of R_2O_3 bases increases, therefore, the R_2O_3/SiO_2 ratio decreases with increased fineness. The base exchange capacity for these particles varies inversely as the R_2O_3/SiO_2 ratio.

3. The finer soil particles have a greater base exchange capacity per gram than the coarser particles.

4. The finer soil particles have a lesser base exchange capacity per surface area than the coarser particles.

5. In general our data shows that the base exchange capacity of a soil is largely associated with the lighter minerals. However, there is some data presented to indicate the presence of a heavy mineral active in base exchange.

TABLE I.—Description of designations used for soil separates

DESIGNATION.[1]	Original soil.	Cation saturating soil.	Settling time of particles.	Suspension time of particles.
Oswego H.........1	Oswego........	Hydrogen......	6.67 min.	Under 6.67 min.
Oswego H.........2	Oswego........	Hydrogen......	40 min.	6.67 min.
Oswego H.........3	Oswego.........	Hydrogen......	4 hours	40 min.
Oswego H.........4	Oswego.........	Hydrogen......	24 hours	4 hours
Oswego H.........5	Oswego........	Hydrogen......	6 days	24 hours
Oswego H.........6	Oswego........	Hydrogen......	Over 6 days	6 days
Oswego Ca........1	Oswego........	Calcium........	6.67 min.	Under 6.67 min.
Oswego NH_4.......2	Oswego........	Ammonium.....	40 min.	6.67 min.
Derby H..........2	Derby.........	Hydrogen......	40 min.	6.67 min.
Crawford H... ...2	Crawford.......	Hydrogen......	40 min.	6.67 min.

1. Similar designations were used for all the fifty-four separates.

TABLE II.—Size, composition and base-exchange capacity of soil separates saturated with various cations

Cation saturating soil and sedimentation fraction. (See Table I.)	Oswego soil.				Crawford soil.				Derby soil.			
	Ave. diam. soil particles, mm.	Percent SiO_2	Percent R_2O_3	Base exch. cap., mg. equivs. per 100 grams.	Ave. diam. soil particles, mm.	Percent SiO_2	Percent R_2O_3	Base exch. cap., mg. equivs. per 100 grams.	Ave. diam. soil particles, mm.	Percent SiO_2	Percent R_2O_3	Base exch. cap., mg. equivs. per 100 grams.
H.............1	0.0598	89.15	7.50	5.9	0.0595	81.62	10.70	6.2	0.0529	82.18	10.83	6.7
NH_4...........1	0.0575	88.41	7.78	4.4	0.0578	84.29	9.37	4.6	0.0568	85.44	9.18	4.4
Ca.............1	0.0586	85.95	8.95	9.9	0.0546	79.31	12.13	5.1	0.0568	82.17	10.03	6.8
Ave 1's........	0.0587	87.84	8.08	6.7	0.0573	82.07	10.73	5.3	0.0555	83.26	10.01	6.0
H.............2	0.0239	88.79	6.82	3.8	0.0255	86.47	9.80	5.8	0.0234	81.13	10.85	7.4
NH_4...........2	0.0257	89.56	6.98	8.4	0.0252	89.66	7.73	2.1	0.0279	85.03	9.48	4.6
Ca.............2	0.0277	87.14	7.70	4.9	0.0269	86.03	8.45	5.8	0.0256	80.56	11.98	7.3
Ave. 2's.......	0.0258	88.50	7.17	5.7	0.0259	87.39	8.66	4.6	0.0256	82.24	9.77	6.4
H.............3	0.0110	80.79	10.80	10.2	0.0110	76.90	12.40	14.6	0.0102	66.10	17.93	18.6
NH_4...........3	0.0111	86.39	10.70	6.8	0.0107	84.32	9.48	8.3	0.0109	75.93	12.80	13.3
Ca.............3	0.0118	84.04	10.85	7.3	0.0108	74.51	13.88	13.4	0.0111	65.89	16.35	11.4
Ave. 3's.......	0.0113	84.07	10.78	8.1	0.0108	78.58	11.92	12.1	0.0107	69.31	15.69	14.4
H.............4	0.0042	72.90	15.63	....	0.0045	63.45	18.50	14.9	0.0041	56.69	23.35	23.4
NH_4...........4	0.0044	73.70	15.20	13.9	0.0044	....	....	17.2	0.0045	....	....	18.4
Ca.............4	0.0045	74.38	14.23	12.0	0.0046	....	....	16.2	0.0038	....	....	....
Ave. 4's.......	0.0044	73.66	15.02	13.0	0.0045	63.45	18.50	16.1	0.0041	56.69	23.35	20.9

TABLE III.—Composition and base exchange capacity of soil separates fractioned according to specific gravity

Soil fractions from indicated separates and of indicated specific gravity.		Fractions from ammonia saturated Derby soil.			Fractions from ammonia saturated Oswego soil.			Fractions from ammonia saturated Crawford soil.			Fractions from hydrogen saturated Crawford soil.			Fractions from calcium saturated Crawford soil.		
Sep.	Sp. Gr.	Percent SiO_2	Percent R_2O_3	B. E. cap. (1).	Percent SiO_2	Percent R_2O_3	B. E. cap. (1).	Percent SiO_2	Percent R_2O_3	B. E. cap. (1).	Percent SiO_2	Percent R_2O_3	B. E. cap. (1).	Percent SiO_2	Percent R_2O_3	B. E. cap. (1).
1	2.0 to 2.4	65.34	11.35	....	77.10	7.80	9.78	70.56	9.22	16.44	62.55	13.27	13.44	60.95	16.45	....
1	2.4 to 2.5	70.59	17.12	4.44	78.17	11.35	6.89	77.01	11.07	....	68.30	16.32	10.22	66.45	16.32	....
1	2.5 to 2.6	69.60	16.37	2.72	83.28	5.45	3.06	72.58	18.42	4.56	75.63	14.02	4.77	69.84	15.70	....
1	2.6 to 2 7	90.73	8.00	0.88	90.68	4.20	2.33	90.74	10.57	3.61	89.47	4.50	2.17	89.02	6.62	....
1	2.7 to plus	60.92	32.47	1.17	70.79	22.95	....	48.78	29.60	....	51.23	31.60	0.89	49.69	32.87	....
2	2.0 to 2.4	70.20	9.55	12.29	71.01	12.82	14.0	81.71	7.07	....	....	....	....	64.28	15.57	....
2	2.4 to 2.5	69.15	12.29	....	73.80	16.05	15.1	73.15	10.22	....	....	....	....	64.70	....	....
2	2.5 to 2.6	67.73	16.75	....	71.88	15.17	....	70.04	16.35	....	71.84	....	....	72.72	....	....
2	2.6 to 2.7	86.72	8.57	1.61	89.79	4.45	2.38	92.30	5.07	....	88.29	6.25	2.67	88.56	5.27	....
2	2.7 to plus	74.30	18.32	....	82.98	22.60	....	73.15	20.82	....	69.44	19.22	2.67	76.39	17.72	....
3	2.0 to 2.4	62.08	....	....	68.86	....	....	68.84	....	....	59.62	....	....	60.65	....	....
3	2.4 to 2.5	63.95	14.30	....	67.27	....	....	67.08	....	....	54.76	....	....	58.97	....	....
3	2.5 to 2.6	71.63	16.30	7.56	73.25	....	....	72.48	....	....	68.42	....	....	72.64	....	....
3	2.6 to 2.7	83.59	9.55	3.22	88.47	7.15	2.06	87.28	....	....	85.34	....	....	87.19	....	....
3	2.7 to plus	71.58	19.32	....	78.35	....	....	....	....	....	72.54	....	....	68.80	....	....

(1) Base exchange capacity expressed as mg. equivalents per 100 grams of soil.

TABLE IV.—Base exchange capacity of soil separates in relation to diameter or particle (a)

Radius in mm. (c)	0.0286	0.0149	0.0055	0.0022
Particles per gm. (millions) (b)	4	28	552	8,696
Surface per gm. soil separates, sq. mm	404	774	2,097	5,218
B. E. cap., m. eq. per 100 gm	6	5.6	11.5	16.4
B. E. cap., m. eq. per 100,000 sq. cm. soil surface,	14.88	7.22	5.52	3.12

(a) Figures given in the table are averages from nine separates given in Table II.
(b) Particles per gm., surface per gm., etc., are calculated on assumption that particles are spheres with a specific gravity of 2.6.
(c) Average from measurements of 250 or more particles.

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The Fourth Annual Summary of the More Important Insects of Kansas Covering the Year 1934[1]

ROGER C. SMITH and E. G. KELLY,[2] Kansas Agricultural Experiment Station, Manhattan, Kan.

SUMMARY OF THE WEATHER OF KANSAS FOR 1934[3]

While January had a cold wave on the 30th and 31st, it had in general mild temperatures, much sunshine, but little moisture. February had a cold wave on the 26th and 27th, but with the most generous snowfall for this month in 6 years. The first three weeks were exceptionally mild, but there was a severe cold spell the last of the month, closing the mildest winter on record. March was abnormally dry and windy. There were many dust storms. Subsoil moisture was markedly deficient. Temperatures were a little above normal, but the last week was almost as cold as the first. Less moisture fell in April than fell in this month in 24 years, and there were frequent and widespread dust storms. The month was followed by the warmest May on record. Moisture was deficient in spite of some timely rains in all but southeastern Kansas. The record-breaking high temperatures of the summer began the last few days of May and continued until the second week of August. The period may be described as the hottest and driest period ever recorded in the state, and within the memory of the oldest inhabitants. At Manhattan, 15 days of June, 27 days of July and 19 days of August had maximum temperatures of 100° F., or higher; of these, 23 days had a maximum of 110° F., or higher. The total rainfall for June, July and August was 3.54 inches. Emporia and Manhattan repeatedly had the maximum temperatures in the state during the summer. September and October were pleasant months, with good rainfall. Much wheat was planted in August and early September. Fall gardens flourished in eastern Kansas. The first killing frost occurred 2 weeks later than normal—October 28. November was unusually mild and sunshiny, with abundant precipitation in the eastern third of the state. December had seasonable weather, with little precipitation, some dust storms and cloudy weather in the eastern half of the state. There were two cold waves, on the 6th and 7th and 25th and 26th.

Crops were poor generally, or complete failures, except the wheat crop in south-central and southern Kansas where the yields were good. Good forage yields occurred only in southeast Kansas; elsewhere alfalfa cuttings were exceedingly short. Many acres of Russian thistle were cut in the western half

1. Contribution No. 436 from the Department of Entomology.

2. Doctor Kelly is Extension Entomologist and not a member of the Agricultural Experiment Station. His contributions were making important state-wide observations, the final approval of the county summary figures, and a critical reading of the final report. Grateful acknowledgment is made to Dean H. J. Umberger, the county agents, vocational agriculture teachers, the farmers and entomologists who made reports, especially to H. R. Bryson and the staffs of the Department of Entomology and Field Station Laboratory of the Bureau of Entomology and Plant Quarantine for information supplied. Messrs. R. C. Bushland and Lynn Robinson assisted in making the plate. This report embodies results obtained on Agricultural Experiment Station Project No. 6.

3. The weather data are from the monthly reports of S. D. Flora, United States Department of Agriculture Weather Bureau, Kansas Section 48 (Nos. 1-13), 1934.

TABLE I.—Summary of weather data for the state of Kansas for the period September 1, 1933, to December 31, 1934

Month.	Temperature (in degrees).					Precipitation (in inches).					
	State average.	Maximum.	Minimum.	Average for 47 years.	Departure from normal.	State average.	Average for 47 years.	Departure from normal.	Eastern third.	Middle third.	Western third.
September	74.3°	103°	34°	69.6°	+4.7°	2.25	2.77	—0.52	3.52	1.90	1.33
October	57.8°	89°	21°	56.9°	+0.9°	0.86	1.96	—1.10	1.57	0.52	0.50
November	47.2°	84°	12°	43.2°	+4.0°	0.72	1.26	—0.54	0.69	0.50	0.97
December	39.6°	78°	0°	24.3°	+15.3°	1.27	0.86	+0.41	1.58	1.18	1.04
January	36.3°	74°	—7°	30.3°	+6.0°	0.43	0.66	—0.23	0.58	0.60	0.11
February	36.0°	82°	—20°	33.0°	+3.0°	1.15	1.02	+0.13	0.93	1.16	1.36
March	44.1°	90°	4°	43.0°	+1.1°	0.70	1.46	—0.76	0.81	0.74	0.55
April	57.1°	96°	21°	54.8°	+2.3°	1.27	2.62	—1.35	2.17	1.24	0.39
May	69.6°	106°	35°	63.8°	+5.8°	2.82	3.69	—0.87	4.21	3.00	1.24
June	80.5°	110°	47°	73.8°	+6.7°	2.73	3.97	—1.24	2.54	3.27	2.39
July	87.2°	119°	47°	78.7°	+8.5°	1.13	3.30	—2.17	1.74	0.91	0.74
August	83.6°	117°	40°	77.4°	+6.2°	1.32	3.17	—1.85	1.31	1.22	1.44
September	65.2°	102°	26°	69.6°	—4.4°	4.18	2.80	+1.38	6.97	4.12	1.45
October	62.3°	97°	7°	57.0°	+5.3°	1.29	1.95	—0.66	1.91	1.30	0.66
November	47.3°	87°	13°	43.3°	+4.0°	2.58	1.29	+1.29	4.84	2.24	0.66
December	33.1°	72°	—5°	32.8°	+0.3°	.42	.86	—0.44	0.68	0.43	0.15
Totals for the calendar year						20.02	26.79	—6.77	28.69	20.23	11.14

TABLE II

Allen	[illegible]
Anderson	[illegible]
Atchison	[illegible]
Barber	[illegible]
Barton	[illegible]
Bourbon	[illegible]
Brown	[illegible]
Butler	[illegible]
Chase	[illegible]
Chautauqua	[illegible]
Cherokee	[illegible]
Cheyenne	[illegible]
Clark	[illegible]
Clay	[illegible]
Cloud	[illegible]
Coffey	[illegible]
Comanche	[illegible]
Cowley	[illegible]
Crawford	[illegible]
Decatur	[illegible]
Dickinson	[illegible]
Doniphan	[illegible]
Douglas	[illegible]
Edwards	[illegible]
Elk	[illegible]
Ellis	[illegible]
Ellsworth	[illegible]
Finney	[illegible]
Ford	[illegible]
Franklin	[illegible]
Geary	[illegible]
Gove	[illegible]
Graham	[illegible]
Grant	[illegible]
Gray	[illegible]
Greeley	[illegible]
Greenwood	[illegible]
Hamilton	[illegible]
Harper	[illegible]
Harvey	[illegible]
Haskell	[illegible]
Hodgeman	[illegible]
Jackson	[illegible]
Jefferson	[illegible]
Jewell	[illegible]
Johnson	[illegible]
Kearney	[illegible]
Kingman	[illegible]
Kiowa	[illegible]
Labette	[illegible]
Lane	[illegible]
Leavenworth	[illegible]
Lincoln	[illegible]
Linn	[illegible]
Logan	[illegible]
Lyon	[illegible]
McPherson	[illegible]
Marion	[illegible]
Marshall	[illegible]
Meade	[illegible]
Miami	[illegible]
Mitchell	[illegible]
Montgomery	[illegible]
Morris	[illegible]
Nemaha	[illegible]
Neosho	[illegible]
Ness	[illegible]
Norton	[illegible]
Osage	[illegible]
Osborne	[illegible]
Ottawa	[illegible]
Pawnee	[illegible]
Phillips	[illegible]
Pottawatomie	[illegible]
Pratt	[illegible]
Rawlins	[illegible]
Reno	[illegible]
Rice	[illegible]
Riley	[illegible]
Rooks	[illegible]
Rush	[illegible]
Russell	[illegible]
Saline	[illegible]
Scott	[illegible]
Sedgwick	[illegible]
Seward	[illegible]
Shawnee	[illegible]
Sheridan	[illegible]
Sherman	[illegible]
Smith	[illegible]
Stafford	[illegible]
Stanton	[illegible]
Stevens	[illegible]
Sumner	[illegible]
Thomas	[illegible]
Trego	[illegible]
Wabaunsee	[illegible]
Wallace	[illegible]
Washington	[illegible]
Wichita	[illegible]
Wilson	[illegible]
Woodson	[illegible]
Wyandotte	[illegible]

The summary numbers carry the same meaning as in previous reports, viz.:

0. The insect was neither seen in the county nor reported present.
1. A few individuals were seen or reported, the species being scarce.

In the averaging of reports, 0 and 1 reports were not included.

2. The species was plentiful, but no noticeable damage was done.
3. The species was abundant, some damage was seen or reported.
4. The species occurred in local outbreaks, important damage was done in some fields.
5. The species was in general outbreak or was as plentiful and destructive as has occurred formerly when particularly plentiful.

of the state, or used for pasture, and this weed crop sold at as much as $10 a ton, though the usual price was $4.50 per ton. The state was spared wholesale loss of livestock from starvation by governmental aid and the removal of many thousands of cattle from western Kansas to the excellent fall pasture in the eastern half of the state on early sown wheat which was utilized throughout the winter, except possibly for a total of about two weeks. Bluestem pastures in the flint hill section of the state were good. There was a shortage of water for livestock during most of the year. There was a poor crop of potatoes, a good crop of apples in northeast Kansas, a good second cutting seed crop of alfalfa in the eastern half and a fair, though short, sorghum crop in all but the western third of the state, while corn and oats over most of the state were nearly total failures.

The year 1934 was a "critical year."[4] It threatened complete losses of crops, but the yields of all were surprisingly good. There was the threatened loss of the peach crop by freezes the latter part of January and on February 24, but Kansas had a good peach crop; the threatened loss of alfalfa stands by pea aphids and drought, but there was little loss of stands observable in 1934, but a total loss of the first cutting over a considerable area; the threatened loss of wheat by chinch bugs and drought, but a fair crop in eastern Kansas, especially south-central Kansas, resulted; the threatened heavy loss of corn and sorghums by the large outbreak of chinch bugs, but the actual loss probably was less than 1 percent of the acreage; the threatened loss of the apple crop by hail (June 20) and codling moth in northeast Kansas, but a fair crop was harvested.

Migratory birds apparently avoided Kansas in 1934, probably because of the scarcity of insect food.

The manner of gathering, assembling and interpreting the data on the population of the more important insects of Kansas did not differ in any material way from that used in previous reports.[5]

SOURCE OF THE DATA

Questionnaires were returned as follows:

	July	October
By county agents	76	78
By vocational agriculture teachers	97	18
By entomologists	13	8
By farmers	24	11

Grand total of questionnaires summarized, 325.

EXPLANATORY NOTES ON THE MORE STRIKING INSECT POPULATION DURING 1934[6]

The alfalfa caterpillar, especially the butterflies, were noticeably scarce, in spite of little disease.

Ants of several kinds were unusually troublesome during 1934, probably because they were driven into homes by the extreme weather. The common

4. Taylor, Walter P. Significance of extreme or intermittent conditions in distribution of species. Ecology 15 (4): 374-379. 1934.

5. Smith, Roger C. Summary of the population of injurious insects in Kansas for 1933—the third annual summary. Jour. Kans. Ent. Soc. 7 (2): 37-51. 1934.

6. Many observations reported by Professor Bryson and included in the Bureau of Entomology and Plant Quarantine Insect Pest Survey, Vol. 14 (1-10), 1934, are not given in this report.

red ant, or pavement ant (*Tetramorium casepitum*), was the most common offender. Pharaoh's ant, the black carpenter ant, and the yellow ant also occasioned more correspondence than usual. The latter species is apparently on the increase. While most reports and specimens of it came in during the spring, these ants were observed swarming at Manhattan as late as June 21.

Kafir ants were reported in July damaging Sorgho in Sedgwick and Elk counties. They destroyed kafir seed planted for late feed during July in south-central Kansas. Slow germination contributed to the injury.

Ant-lion pits were exceptionally plentiful, being the subject of more correspondence than for many years.

Aphids were exceptionally plentiful during 1934, the outbreaks of the pea aphid (*Illinoia pisi*) and greenbug (*Toxoptera graminum*) being outstanding. Spring gave promise of an "aphid year," especially in the eastern half of the state.

Pea aphids were observed in greater numbers than usual at Manhattan on February 15, particularly in fall-planted alfalfa, this being the earliest date winged forms have so far been collected. Alfalfa made little growth because of the dry weather, and by early April practically every field in the vicinity was heavily infested and severe damage appeared imminent. The aphid outbreak developed rapidly in 47 counties in the eastern half of the state, west as far as Ellis, and by the last of April much alfalfa appeared to have been lost. Practically every field of alfalfa was infested. The aphids were not confined to spots as in previous years, but were fairly uniform all over fields from the start, particularly in the lower parts of fields. The convergent lady beetle had been plentiful from the start and increased rapidly. From May 5 to 7 these beetles overcame the aphids and disposed of them so thoroughly that it would have been difficult to have found a hundred. This was the most spectacular control by a predator which has occurred in Kansas for many years. The nearly complete obliteration of the outbreak apparently occurred throughout the infested territory at the same time. These beetles reached a maximum population of 200 to the square foot and it was determined by counts of larvae, pupae and adults that many fields averaged 15 to 20 to the square foot over the entire field. The beetles scattered quickly following the failure of the aphid supply and many larvae and adults became cannibalistic.

A good rain fell on the 12th of May and alfalfa began at once to grow, but the first crop was either a total loss or it was light.

Pea aphids were abundant and destructive, particularly in Douglas county, to peas and tulips. In fact, pea aphids scattered widely and were found on many plants, on some of which they attempted feeding and colonization.

The aphids continued scarce and none whatever could be found from about July 1 until the middle of September. They were scarce all fall, however, in spite of favorable weather for them.

A striking feature of the outbreak was that the alfalfa stands were not killed. This emphasizes the importance of delaying the plowing up of aphid injured stands. However, fields with spots of killed alfalfa were observed by Professor Dean the latter part of June from St. George eastward in the Kaw Valley. Marked resistance and susceptibility were observed in the alfalfa variety plants of C. O. Grandfield, Bureau of Plant Industry at the Kansas Agricultural Experiment Station Agronomy farm, to the pea aphid. Ladak,

some Turkestans, Cossack and some selections of Kansas Common were less infested and less damaged, while the Commons were more heavily infested and more injured. Stands, which had been weakened by bacterial wilt, on the lowlands, were particularly adversely affected.

There was a widespread outbreak of the green bug (*Toxoptera graminun*) in wheat and oat fields and in bluegrass lawns from February to June, the first to occur since 1916. The season was favorable for it. The familiar enlarging spots of damaged wheat were observed by the middle of February and by the first of March the situation was alarming. They occurred during the spring in 43 eastern and southern counties, being worst in southeastern Kansas. Spots were observed in April in Cherokee, Douglas and Riley counties. The junior author reported infestations from Abilene to Ellsworth, and from Oklahoma to Nebraska. They were graded at "5" from Jackson, Shawnee, Franklin, Chase, and Cloud counties, at "4" in Saline, Clay, Dickinson and Ottawa, and at "3" in Barber, Morris, Waubaunsee, Pottawatomie and Riley counties.

By early May the green bugs were a less serious check on wheat than the drouth, but their damage to oats and bluegrass was becoming marked. Lawns were damaged in Sumner, Sedgwick, Greenwood and Cowley counties. The parasites and lady bettles exerted strong, natural checks. Dr. R. H. Painter observed colonies of green bug (*Toxoptera graminum*) in wheat in October in Riley county.

Aphids on arborvitae appeared again in Riley, Labette, Cowley, Sedgwick, Harper and Wyandotte counties. Bees and flies swarmed over the arborvitae for the honeydew. The aphids were brought under control by lady beetles flying in from alfalfa fields.

Apple grain aphids were more plentiful than in previous years, particularly in the Arkansas river valley. Their injuries were augmented by a severe freeze on April 27, when a temperature of 27° F. was reached.

The apple curculio built up its population in 1933 and no losses of importance occurred during hibernation. The new generation in August was small and did no damage. The population and damage for the year was considerably less than in previous years.

The cabbage aphis was destructive to radishes in gardens at Manhattan during April. These insects and dry weather practically destroyed the radish crop. The junior author rated them at "4" for the whole eastern half of the state. Lady beetles (*H. convergens*) destroyed the aphids by May 8. This aphid was plentiful on turnips in the fall, and did serious damage in most places to the fall turnip crop. They were especially plentiful in Osage, Washington, Marshall, Nemaha, Atchison, Douglas and Riley counties.

Aphid attacks on spinach were graded at "3" in Labette county during the spring, and at "3" on tomatoes in Coffey county.

The corn-root aphid was destructive in southeast Kansas, especially in Neosho and Labette counties. Several fields of corn were reported completely killed during June.

Blister beetles became plentiful the last of July, but the population of the various species was about average. The striped blister beetle probably was slightly above the average in Riley county and west.

Tree borers were more plentiful and destructive all over the state than in

recent years. The most common were the flat-headed apple tree borer, and the elm borer, both of which attacked trees weakened by canker worm defoliation and drouth. The disastrous effect of the borers, particularly the former, will continue for several years. At Manhattan these borers were most serious in elm, maples (especially soft maple), oaks (especially pin oak) and walnut. Three or four times the usual number of inquiries in regard to borers came in during the year.

Borers were graded at "3" on apricot in Shawnee and Osage counties; at "4" on cottonwood in Clark, Cowley and Marshall counties, and reported from Ford, Grant, Gove, Sheridan and Thomas counties; at "3" on locust in Lyon, Ellsworth and Seward counties, and reported from Ford, Stanton and Thomas counties; at "4" on maple in Riley and Pawnee counties, and reported from Kingman county; at "4" on plum in Clark county.

The peach-tree borer was plentiful in southeastern Kansas. Their damage was augmented by the dry weather.

The squash-vine borer was plentiful in squash and pumpkins during the late summer and fall.

Bot flies were the most numerous they have been for a number of years. The distribution was statewide. The nose bot was annoying to horses during wheat planting in September in northwest Kansas.

Boxelder bugs were practically absent during the summer, fall and winter the first time for many years. Not a single letter was received about them. None was seen about any buildings in the fall. Since a fair population passed the winter of 1933, there must have been nearly a 100 percent mortality of the eggs and nymphs during the summer.

Cabbage worms were very scarce and the familiar white butterflies were scarce, due to the almost total failure of the cabbage crop.

Army cutworms were present in average numbers, or less. They were collected in moderate numbers in Riley county during February and March, but the population appeared to dwindle almost everywhere and no damage was done except slight damage to wheat in Reno, Sedgwick, Cowley and Cloud counties. Abnormally large numbers of moths of this species were observed in Russian olive trees at Garden City, where they appeared to be feeding on the nectar in early June. Many were hiding in outbuildings, also, indicating a high local population of cutworms. Somewhat smaller numbers were observed in other localities in north-central Kansas.

Less damage was done to corn by cutworms than usual because corn planting was delayed by dry weather and the dry, hot weather was unfavorable for cutworms.

The variegated cutworm was practically absent over the state, being below normal in numbers.

Moths of *Feltia ducens* were numerous at lights during September and October at Manhattan.

H. H. Walkden, of the Bureau of Entomology and Plant Quarantine, collected *Scotogramma* larvae in September on lamb's quarter, and reported taking the moths at lights in other years. The species is, therefore, not a new invader, as was erroneously mentioned in last year's report.

Cankerworms occurred in serious outbreak in Riley, Shawnee, Douglas and

Dickinson counties, but were less plentiful in other counties. Fall cankerworm moths began to appear January 1 and the spring cankerworm moths on January 11. They emerged rapidly because of the mild weather and many trees were not banded soon enough. The peak of emergence of the fall cankerworm moths was reached about January 17, while the peak of the spring cankerworms came about March 3. There were as many as 506 female moths on one tanglefoot band in one day early in March according to Dr. R. L. Parker, and a maximum of 8,436 spring and 62 fall cankerworm female moths on one tree for the season. Severe dust storms, the warm weather, and heavy emergence made it difficult to keep the bands in a sticky condition. The bands were estimated to have been 80 percent efficient, however, but the 20 percent of the moths laid enough eggs to cause defoliation of the trees. A sprayer was purchased by the city of Manhattan on May 9, and spraying began May 10, but this was too late.

The eggs began hatching the latter part of March and most were hatched by the middle of April. Many larvae starved because elm trees were slow in leafing, due to the excessively dry spring. There was a good crop of elm seeds, however, upon which the larvae fed for a time. In addition to elms, hackberry and honey locusts were severely attacked.

By May 8 the larvae were about half to two thirds grown, and defoliation was becoming severe. Many trees were completely defoliated and many did not put out new leaves. Professor Quinlan found that 87 of the 3,705 trees on the college campus had succumbed to canker worms, borers and drought. In the city of Manhattan, Professor Dean estimated the loss at about 800 or 1,000 trees killed during 1933 and 1934. Seriously weakened trees will die in 1935 and later from causes initiated chiefly in 1934, or earlier.

A survey trip to McPherson, Kan., revealed no injury to trees along the way. In the region of Wichita, damage occurred only in poorly cared for orchards.

Carpenter worms damaged ash trees severely at Stockton, Kan., in June.

Cattle grubs increased somewhat during 1934. The population in farm animals was particularly high in the western third of the state. Calves were exceptionally "grubby" in the fall.

There was a widespread outbreak of chinch bugs in Kansas in 1934. Hot, dry weather is favorable to these pests. More bugs hibernated during the winter of 1933-1934 than for 5 or 6 years, especially in southeastern and central Kansas, and there was little mortality. They began leaving winter quarters about the middle of March. A heavy flight occurred April 5 to 7. A large generation was reared in wheat, barley, rye and bluegrass fields, and a severe outbreak during June was in prospect. They began to move out of wheat fields 2 or 3 weeks earlier than normal, due to the wheat maturing as a result of the severe drought. The first migrations occurred at Manhattan June 3 or 4. The peak of the migration at the college farm occurred about June 14, after which there was a rapid decline, such that they were practically all out by June 19. The migration continued from oat fields until about June 21, when barriers were discontinued.

Rains between June 11 and 18 stopped the migrations temporarily, rendered dust barriers useless and started crab grass which held the bugs back in the area south and east of Riley county. Chinch-bug fungus was observed in this

area, especially in Greenwood and Lyon counties. The junior author reported that there had been 54,491 rods of dust barriers and 206,199 rods of creosote barriers operated against chinch bugs during the season.

The 435,246 gallons of chinch-bug oil supplied by the federal government reached the state for distribution beginning June 18, and to Riley county June 19. This was barely in time for most of the state, but was a little late for Linn and Riley counties. This oil was used in 53 eastern and southeastern counties.

The loss of corn in the state, due to extensive use of the dust barriers and later by oil barriers, was small, probably being less than 1 percent. Fairly severe damage to corn was reported in Johnson and Douglas counties.

The second generation of chinch bugs actually decreased in size during July and August because of the extreme hot, dry weather. Soil surface temperatures of 151° were reached the last of July, and both eggs and nymphs were killed. The drouth killed their food plants, especially corn.

Even milo at the college farm grew away from the bugs, according to Dr. R. H. Painter. In the fall a fair number of bugs went into hibernation, especially where there was crab grass. The fall distribution was, according to W. T. Emery, Bureau of Entomology and Plant Quarantine, 14 bugs to the square foot in two counties; 45 to the square foot in 5 northeast counties; 68 in 6 southeast counties, and 365 in Marshall county. The extension entomologist reported them numerous during the late fall in 25 northeastern and eastern counties.

Clover-leaf weevils were plentiful in the early spring, especially in Leavenworth and Riley counties, but they soon dwindled to very small numbers. Clover root curculios were exceedingly scarce all season.

Codling moths came out April 25 in the Wichita district and May 7 in Doniphan county, which was about 2 weeks earlier than usual. The overwintering population was larger in northeast Kansas than for years. The first generation was large and considerable damage, particularly in neglected orchards, occurred in the Arkansas Valley district in July. Tree scraping and burning of the refuse by CWA relief workers destroyed many larvae. Second-brood damage in northeast Kansas was increased by hail injury. P. G. Lamerson, Kansas Agricultural Experiment Station, of Troy, stated that for the season the greatest injury was confined largely to shaded areas and in the center of trees. But the temperature was too high for the larvae. The moths stopped laying eggs and the population decreased. A good crop of apples with 85 percent free of damage was not uncommon. There were three full broods and a partial fourth. Growers sprayed 9 times. There was a heavy carry-over of worms during the winter of 1933-1934 only where there was a large crop of apples and previous heavy infestation.

Corn billbugs destroyed some corn in southern and southeastern Kansas. They were most numerous along the Walnut river and Slate creek in Sumner county and along the Verdigris and Neosho in southeast Kansas and in the bottom lands of tributary creeks.

Corn-ear worms appeared in numbers about the middle of June doing more plentiful rag injury to corn than usual. According to R. H. Painter, corn at the college was practically 100 percent attacked. The moths appeared earlier than usual and persisted during early June in larger numbers than usual. The

population of larvae was high only where there were ears of corn, but the moths were exceptionally plentiful at lights and flowers in September and October. The moths probably did not breed in Kansas because of the corn failure, so the presence of large numbers is evidence of their migration from other states. The numbers in alfalfa during the fall were about average. They attacked the fruit of tomatoes and string beans in northeast Kansas during the fall.

Corn rootworms were scarce during 1934, and no damage was done.

Crambid larvae of unknown identification developed in outbreak numbers in the bent grass on the grass greens of golf courses at Topeka and Kansas City, June 28.

False wireworms were less plentiful and less destructive during 1934 than in 1933. There was considerable disking during May to destroy the pupae.

Flies on domestic animals were below normal, except for a few days in late June. Many farmers did not use fly nets all summer. House flies were much below normal in numbers also.

There was not a single inquiry received during the year on screwworm flies, though the extension entomologist reported a small outbreak in Lincoln and Ottawa counties.

The extension entomologist observed that horn flies were abundant in Kansas during the fall.

Grasshoppers threatened to be plentiful during 1934, but because of a severe adverse season and an early successful control campaign, using 1,000,000 pounds of bran and 50,000 pounds of white arsenic supplied by the federal government, the population was below normal and no damage was done. Eggs began hatching early because of the warm, dry spring, the nymphs grew rapidly and adults of the red-legged grasshopper were observed at Manhattan on May 31, which is probably the earliest record. Adults of the two-lined grasshopper were observed on June 16. Poisoning began in western Kansas about June 1 and in eastern Kansas about June 20, and continued until the last of July. The population consisted largely of the migratory, two-lined and Packard's grasshoppers. Excellent results were obtained with the poisoned bran mash because of the shortage of natural food.

Over 1,250,000 pounds of bran and 62,500 pounds of white arsenic were used in the state—750 tons of poisoned bran mash. The season was favorable for excellent results with the mash, and the grasshopper population was quickly reduced to below normal. Grasshopper parasites and predators were unusually plentiful and effective during July and early August.

While every year there occurs two generations of the migratory grasshopper, there was observed a second generation of the two-lined grasshopper during 1934. This species oviposited first in June and July and again in September and October, while the differential grasshopper did not lay eggs until the last two weeks of September. The adult hoppers found shelter in and under bushes and Russian thistle, and they laid their eggs most plentifully in such places.

A second allotment of 250 tons of ready-mixed grasshopper bait supplied by the federal government was supplied to 39 counties during late summer, but about half of this amount was left over for use in 1935.

There were few grasshoppers during the fall, and an egg survey trip by

D. A. Wilbur and R. C. Bushland revealed the fact than few overwintering eggs were deposited. The population was actually less than for many years. This survey covered 33 western counties and 21 eastern counties. As a result of the survey, it was determined that 1,020,340 pounds of poisoned bran mash would be needed in 1935.

D. A. Wilbur discovered by semiweekly sweepings that in 1933 grasshopper nymphs collected in pastures increased in numbers normally to a peak on June 22, when they dwindled to zero in late September. In 1934 there was a peak reached June 5, after which numbers dwindled nearly to zero and a second peak was reached October 7. This is interpreted as an indication that the majority of the adults maturing in June died during the summer, particularly in early August. There were some eggs deposited which hatched largely in September and the nymphs perished in the cold weather during November. This is further indication of a low grasshopper population for 1935.

Halicta faliacaca, a green flea beetle attacked apple seedlings at St. George, Topeka, Wathena, and Perry according to G. A. Dean, doing severe damage. They were plentiful at Manhattan on many plants, especially poppies. This is the most severe damage since 1928.

The harlequin bug severely attacked cabbage in the eastern half of the state during the latter part of June and all of July. Locally these insects were bad about July 10, being more plentiful than usual, and during August on turnips.

Pentatomids were exceptionally plentiful in alfalfa fields. They were favored by the hot, dry weather. By the latter part of July, sweepings of alfalfa consisted largely of stink bug eggs and nymphs.

Hessian fly was at the lowest population for years. Southeast Kansas had a population of about 10 percent. Elsewhere the population was 1 and 2 percent. While it was expected that many farmers would plant wheat before the safe date, half as many farmers planted on the safe date as followed this planting guide in 1933.

Planting began about the 10th of August and continued into early November in rare cases in the West. Fall wheat made a luxuriant growth in the eastern half of the state and provided fall pasture throughout the winter, thus solving the food problem for cattle and horses for thousands of farmers. It has been stated that farmers realized a dollar a bushel for their wheat crop for fall and winter pasture alone.

Hessian fly increased rapidly as a result of the fall rains, and J. R. Horton, Bureau of Entomology and Plant Quarantine, reported a small second fall generation around Wichita. About 5 percent of the overwintering forms were of the second fall generation. The only locality where damage is threatened in 1935 is in southeast Kansas. In Riley county the fall population was about equal to that of a year ago, but in Dickinson and Geary counties, the fall population was larger, especially in the Solomon river valley.

Leaf hoppers were numerous all over the state during 1934. They were observed and reported plentiful on alfalfa, wheat, grape and potatoes. Hopperburn on potatoes was observed to be prevalent in the northern two tiers of counties and in southern Kansas in late May and June.

Leaf hoppers were particularly destructive to English ivy on buildings. Many vines were largely defoliated during August. These insects were plenti-

ful at this time in northeast Kansas on strawberry plants. They were reported at "3" on eggplant and radish in Shawnee county, at "3" on shrubs from Pottawatomie and Sedgwick; at "2" on tomatoes in Ford and Barber, and at "3" on wheat in Trego county. They were reported as "3" on elms in some sections in October. Leaves coated with honeydew were seen from Stafford, Pawnee and Norton counties.

Lice (Anoplura) on cattle and hogs apparently were below normal in population for the year, but were abundant in many sections during the early spring. Cattle lice were reported at "3" from Norton, Russell, Montgomery and Seward counties; at "3" on hogs in Wilson, and at "2" in Cloud and Logan counties.

Mites (red spider) on plants were exceptionally plentiful during 1934. They killed more pansies, evergreens (cedars and arborvitae especially) and apple trees than for many years. Dean estimated that about 1,000 acres of the apple trees of the Arkansas valley region, which includes Cowley, Sumner, Sedgwick and Reno counties, were killed by this pest together with the drought during 1934. The hot, dry season made spraying with oil impossible, except in late June, and the small 25 percent set of apples made the application of about three oil sprays difficult economically. Many evergreens were killed by mites in the spring and summer. Pansies were more damaged than in recent years. Garden beans, peas and other plants were severely attacked. The season was favorable for the mites, and the drouth made the injuries worse. Mite damage in April and May is unusual in Kansas; normally the adult mites go into hibernation in August.

Mites attacked wheat in McPherson and Saline counties. They did less damage in Lincoln, Mitchell and Dickinson counties. They appeared with Toxoptera.

Mites on domestic animals were below normal. Little sheep scab was reported. There were a few infested sheep in Reno county early in the winter. There was considerable hog mange in the north-central and the southeast counties. Few cattle were infested with mange during the year.

Mosquitoes were in local outbreak in Manhattan near the end of May. They were thought to have bred in the storm sewer which was in the process of construction.

Potato beetles were less numerous than for many years. The eggs and young grubs were early devoured by lady beetles which came from the alfalfa. The dry weather killed the potatoes prematurely and the second generation largely starved. Potatoes were neither sprayed nor dusted in the state. The absence of snow during the winter of 1933-'34 helped to keep down the overwintering population.

The redbud leaffolder (*Gelechia cercerisella* Cham.) occurred in outbreak proportions in the eastern third of the state, with a local outbreak at Hays during 1934. This insect, according to R. L. Parker, has occurred in Kansas since 1889 or earlier, but has not caused serious injury for about forty years. Practically every redbud tree in Riley county had most or all leaves folded by the last of June, and it is estimated that there were three generations of the insect. Many redbud trees died as a result of this severe foliage injury. The insect was scored at "5" in Riley and Pottawatomie; at "4" in Nemaha and Geary; at "3" in Elk, and "2" in Ellis.

The hourglass spider (black widow) was unusually plentiful, and a large number of letters, many with specimens, were received. Apparently this spider occurs over the whole state. The hot, dry weather drove it to basements in larger numbers than usual.

Stored-grain insects were more plentiful during the spring than usual, judging by correspondence, particularly in old grain which was heavily infested with grain weevils. The scarcity of seed for planting makes insect damage all the more serious. The Mediterranean flour moth was less common in mills in Kansas than in former years, but the long-headed flour beetle was particularly plentiful. The hot sun did not kill insects in mills during the summer.

Stored-grain insects were not plentiful during the fall. The wheat was too dry for the weevil. Fall-stored grain, except seed for sowing, was in better condition in the fall than usual. Kafir cane seed which has been held over for sowing, some of it 2 years old, was heavily infested.

The tarnished plant bug was scarcest in years. Only isolated specimens could be taken even in the late fall in alfalfa fields, where they usually concentrate in large numbers. This may be taken as an index as to how unfavorable the season was for plants and most insects. They were fairly plentiful during February and March, but rapidly dwindled when the hot, dry weather began.

Tabanids were less plentiful than usual over the whole state.

Termites probably were more troublesome than usual during 1934. Swarms went forth in spite of the absence of rains or following light showers. Considerable trouble was experienced in their attacks on shade trees, probably prompted by their moisture demands. Many trees were watered also and the moist soil around the tree roots attracted them. Plum, cherry, peach and elm trees were especially attacked.

Miss Olive Falls, a graduate student, found more termites in colonies in the last instar than usual, probably because of the unfavorable swarming conditions and for establishing new colonies. Ordinarily few last instar nymphs occur after May 1.

Thrips were exceptionally plentiful in alfalfa flowers the first half of June. An excellent set of alfalfa seed occurred on the second cutting, in spite of large numbers of thrips, a nearly normal population of plant bugs and very dry weather.

Tomato hornworms were below normal all season, largely due to the failure of the tomato crop in all but the eastern third of the state. They were most plentiful in the fall when fall rains revived the host plants somewhat and they were reported as both plentiful and destructive in northeast Kansas.

Strawberry leaf rollers were abundant in northeast Kansas (Troy, Wathena, Blair) by the middle of March and reached outbreak proportions by the last of April. They decreased rapidly during the summer. Many strawberry beds were killed by the hot, dry weather.

The strawberry weevil (*Anthonomus signatus* Say) was reported doing serious injury in Doniphan county, the first for at least 40 years. Four acres of berries were completely destroyed and 2 acres were partly destroyed.

Striped cucumber beetles were plentiful and destructive. The population probably was more than usual, and the effects of their feeding were intensified

by dry weather. They attacked melons and squashes during June in Riley county.

The 12-spotted cucumber beetles were scarcer than for a number of years during the summer. Both species built up somewhat in the fall to near normal numbers.

Wasps (*Polistes annularis*) were exceptionally scarce. The familiar paper nests were seldom seen.

The wax moth was unusually destructive during 1934. There was a small honey crop, except in regions in the eastern fourth of the state. Many colonies of bees became weak and the wax moth invaded them. The hot weather caused a shortening of the life cycle somewhat.

Webworms were represented in 1934 by a widespread outbreak of the beet webworm in alfalfa and beet fields in the western half of the state during September and October. D. A. Wilbur saw seriously damaged fields of alfalfa in Stafford and Stevens counties during September. The larvae, after defoliating Russian thistles, moved to adjacent fields in army-like fashion. Broom corn, sugar beets and alfalfa, particularly where many Russian thistles occurred, were attacked. This was the severest outbreak of this insect which has occurred in recent years. Specimens were sent in from Kearny and Kiowa counties. There was considerable fear expressed by farmers that the webworms would attack fall-sown wheat, but these larvae do not attack wheat.

Alfalfa webworm moths (*Loxostege commixtalis*) were sent in from Hoxie, Kan., where they were abundant in cherry trees. Consignments of larval tubes were received from Dighton, Kan., April 14; of moths from Bird City and Garden City, May 7 and from Gretna May 2. Correspondents spoke of the large numbers of moths in the grass and trees, and feared damage from them. These moths were conspicuously absent in Riley county during the spring, but there was a heavy flight of alfalfa webworm moths in April and May over the western half of the state in pastures, grasslands and weed patches.

There were few garden webworms or moths observed in the state during the year. The larvae occurred in Riley county during the latter part of July and the moths were taken in fair numbers at trap lights during August and September.

The wheat-straw worm was scarce during 1934. The population was greatly reduced by the 1933 drought.

White grubs were less numerous and destructive than usual. Some damage was done to strawberries in Riley county in May, and to lawns later.

The green June beetle (*Cotinus nitida*) was numerous in eastern Kansas during July and early August. They attacked peaches severely in some orchards, necessitating the picking the peaches before they were ripe to save them. They were observed doing this damage in Allen and Doniphan counties.

There were few webs of the apple tree tent caterpillar in the spring and few fall webworm webs in late summer. No datanas of the usual economic species were seen.

CONCLUSION

The year 1934 will go down in history as the year of the great drought and an abnormal year generally. It was the fourth in a series of increasingly hot, dry years. The winter of 1933-'34 was the mildest one on record. There was marked deficiency of soil moisture, particularly in the subsoil. The spring was cold, dry, and windy, with heavy dust storms. Alfalfa and pastures were slow in starting and made slow growth until May.

Rainfall was below normal in 19 of the last 23 months, the accumulated deficiency being, on December 1, 1934, 8.68 inches. It was deficient every month of the year except in September.

The scarcity of certain injurious insects or their reduction because of heat and drought was the outstanding feature of the year. The following insects and related forms were *more plentiful* than usual: Ants, pea aphid, green bug (Toxoptera) and other aphids, borers in shade trees, bot flies, canker worms, cattle grubs, chinch bugs, green flea beetles, green June beetle, the harlequin bug, Pentatomids in alfalfa fields, leaf hoppers, red spiders, redbud leaf folder, hourglass spider, stored-grain insects, thrips (alfalfa), strawberry leaf roller and strawberry weevil, striped cucumber beetles, wax moth, beet webworm.

The following insects were *scarce or nearly absent:* Alfalfa caterpillar, box-elder bugs, cabbage worms, cutworms other than the army cutworms, clover root curculios, biting flies on live stock, white grubs and May beetles, Hessian fly, maple worms, potato beetle, tarnished plant bug, tomato worms, apple curculio, and wasps.

The following had about an *average population:* Blister beetles, army cutworms, clover-leaf weevils, codling moth, corn-ear worms, grasshoppers, lice on domestic animals, termites.

An Outbreak of the Beet Webworm, *Loxostege sticticalis* L., in Western Kansas in 1934[1]

DONALD A. WILBUR, Kansas Agricultural Experiment Station, Manhattan, Kan.

One of the most widespread insect outbreaks experienced in Kansas in recent years occurred over the western two thirds of the state during the late summer and fall of 1934. It was caused by *Loxostege sticticalis* L., commonly known as the beet webworm. The damage from this outbreak was comparatively slight because the chief host plant was the Russian thistle (*Salsola pestifer* A. Nels.), which was totally destroyed over large areas.

The extent of the webworm outbreak was limited only by the distribution of the Russian thistle, the only vegetation to flourish on cultivated lands over much of the western two thirds of the state during 1934. The wheat stubble, abandoned lands, allotment acres, and roadsides carried unusually heavy growths of this plant. It was also present on much of the land planted to corn and sorgo. By the middle of September the thistles were generally populated by webworms. Lamb's quarters and pigweed, though present only in limited numbers, were also hosts; the former appeared to have been the first species attacked and to have suffered the most serious injury. Occasional minor infestations also occurred in fields of sugar beets and in alfalfa that was excessively weedy with Russian thistles.

The beet webworm is a Lepidopteron of European origin which reached this section by way of the Pacific coast. It has been in this country and in Canada for many years and is now firmly established in the Rocky Mountain and plateau states, where its frequent and serious attacks upon sugar beets have earned its common name, beet webworm. In addition to the plants mentioned, numerous truck and garden crops are also listed as its hosts.[2]

The 1934 outbreak came to the attention of the wheat growers at seeding time and caused them considerable worry. As the horses and machinery moved through the Russian thistles while disking or drilling stubble lands and allotment acres, they jarred to the ground thousands of green and black stripped caterpillars. These worms, though smaller, resembled and acted much like the destructive army cutworms that have frequently destroyed wheat in various parts of the state. Fortunately wheat is not a host plant for the beet webworm.

The writer became aware of an impending outbreak of the webworms during the first week of September. At this time in the Arkansas river valley between Larned and Syracuse, from early evening until midnight the moths swarmed in countless numbers about every available light. The heat and drought of the summer had not restricted the webworms as it did the grasshoppers and many other insects, because the Russian thistles gave them a food supply upon which to complete their development. From the thistles the worms moved to the soil and constructed silken tubes, which were very resistant to desiccation. Within these tubes the larvae pupated and awaited rains.

The general rains of late August and early September over much of western Kansas not only made conditions ideal for the emergence of the webworm moths, but also stimulated the Russian thistles to vigorous growth. Through-

1. Contribution No. 488, Department of Entomology.

2. Hawley, I. M. 1925. The More Important Insects Injurious to the Sugar Beet in Utah. Utah Agri. Exp. Sta. Circ. 54.

out the fall, Kansas weather conditions were ideal for most insects. With suitable weather and with an abundant food supply available, the moths were enabled to deposit a maximum number of eggs, reported to be as high as 700 per female (Hawley 1925). In addition, many parasites and predators that normally attack the beet webworm undoubtedly succumbed to the unfavorable weather conditions of the earlier summer.

From September 12 to October 11 the writer examined thistle fields in two thirds of the counties of western Kansas. Every thistle field examined showed evidence of webworm infestation although not all were equally attacked. Where the attack was most severe only the thistle stubble remained and the ground was black with droppings from the worms.

The smaller thistles were easily destroyed by the webworms, but the larger plants showed remarkable resistance. It was estimated that certain of the larger thistles carried as many as 500 worms per plant and still survived. Many thistles of two and three feet in diameter contained from 100 to 250 worms. In a field in Pawnee county, where the worms developed rapidly and had already gone into the ground by September 19, the examination of one square foot of soil to a depth of two inches under each of three thistles revealed the following numbers of worms:

Size of plant, diameter	No. tubes per sq. ft.	No. free larvae[3] per sq. ft.
15 inches	11	1
24 inches	31	5
22 inches	23	3
Bare ground between thistles	0	0

An average of 20 tubes per square foot gives a population of 871,200 worms per acre. There were undoubtedly hundreds of acres in Kansas in the late fall of 1934 with this many or more worms full grown and successfully established for the winter.

The beet webworms have a seasonal history that is very similar to that of their close relatives, the garden webworms, *Loxostege similalis* Guenee. There are three complete generations each year in Kansas. The third generation, by virtue of its greater numbers, is the most injurious. The larvae pass the winter in the ground in silken tubes and transform to pupae in the spring. The moths appear in late April or May. The first generation of worms occur in June and in early July and develop into moths throughout July. The second generation of worms are present throughout late July and much of August. They emerge as moths in late August and early September. The worms from this generation of moths may persist until nearly frost before going into the ground.

Such an outbreak as here reported would normally be considered as beneficial to the farmers of the state because the chief plant destroyed was Russian thistle. However, due to the general lack of rough forage throughout the area in 1934, thousands of tons of thistles were cut and stacked for winter feed or used for silage. The feeding qualities of infested thistles as well as the yield were considerably reduced by the webworms through the loss of most of the leaves, the general lack of succulence and the excessive percentage of stems. Thus there is the anomaly of a weed becoming a valuable crop, for a season at least, and the insect destructive to the weed becoming a pest.

3. The free worms in the soil were those that had not completed the construction of their tube.

Some Measurements at the Sun City Natural Bridge

JOHN M. JEWETT, University of Wichita, Wichita, Kan.

The natural bridge over Bear creek, about seven miles south of Sun City in Barber county, Kansas, is one of the spots of natural beauty in the state. It was scientifically described by Cragin (1) in 1896 and pictured and described by Grimsley and Bailey (2) in 1899. It is perhaps the largest and best known of several natural bridges in western Barber county and eastern Comanche county. The bridges are associated with other features, such as sinks and underground water channels, all of which are produced through the solution of gypsum beds in the Cimarron series of the Permian system. "Bat caves" of the same part of Kansas and of the neighboring part of Oklahoma are results of the same processes.

From the geological viewpoint natural bridges are but ephemeral features, for they are soon destroyed by the same set of processes which has produced them. It is expected that periodic measurements will show marked changes and that the bridge will not stand for many years. As pointed out by Cragin, the bridge over Bear creek is due to the creek having been diverted into a cave and soon all of the cave roof excepting the part now forming the bridge had collapsed. At the present time there is but a slight thickness of red, gypseous shale above five feet of gypsum which forms the thinnest and weakest portion of the bridge. The gypsum is ominously cracked. The overlying shale is a burden rather than protection to the supporting gypsum. Great blocks of gypsum in the stream bed evidence recent fallings of portions of the supporting rock.

Here are presented measurements published by Cragin in 1896 and measurements taken in May, 1934:

From Cragin's report:

From wall to wall	about 35 feet
Height of bridge over creek bed—	
at highest point	47 feet
at center of bridge	38 feet
at lowest point	31 feet
Width of bridge at middle	35 feet

Measurements made by University of Wichita students in May, 1934:

From wall to wall, including twelve feet of lateral undercutting in one foot of green shale below the gypsum	about 70 feet
Height of arch above creek at highest part of arch	16.4 feet
Thickness of gypsum bed in highest part of arch	5 feet
Width of bridge at middle part	32 feet

Cragin stated that a wagon drawn by a steady team could be driven across the bridge. That would not now be possible. Paralleling the stream in its west (left) valley wall is an underground solution channel 150 or more feet in length. One is able to easily walk through it. The shape of the channel exit below the bridge was observed to have changed noticeably between visits in May, 1933, and May, 1934.

The purpose of this brief report is merely to record some dated measurements for future comparisons.

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1. Cragin, F. W. The Permian System in Kansas: Colorado College Studies, Vol. 6, 1896.
2. Grimsley, G. P., and Bailey, E. H. S. Special report on Gypsum and Gypsum Cement Plasters: University Geological Survey of Kansas, Vol. 6, page 73, and Plates XXVI and XXVII, 1899.

Water Resources of Johnson County During the Drought of 1934[1]

JOHN M. JEWETT and CHAS. C. WILLIAMS, Wichita, Kan.

Johnson county is sixth county from the south in the eastern tier of counties on Missouri state line, and with the exception of a small part of Wyandotte county it is the first county south of Kansas river. The area is 473 square miles. Olathe, about 25 miles southwest of Kansas City, is the county seat.

The topography falls into three divisions: (1) the gently undulating uplands, most distant from the larger streams, (2) the steep slopes along the larger streams, and (3) the nearly smooth terraces and flood plains along the larger streams. The maximum local relief is about 275 feet while on the smoother uplands it is less than 100 feet. The bedrock comprises beds of shale, limestone, and sandstone which in general have a gentle westward dip. Figure 1 shows the general relation of rock layers to topography along an east-west line across the middle of the area. It should be noted that in this diagram the vertical distances are greatly exaggerated in comparison with the horizontal distance. Resistant limestone layers support the plateau-like, undulating uplands called division number 1 above, while division number 2 is generally marked with outcrops of limestone beds, and the nearly smooth areas along the streams are due to the partial filling of stream valleys. The valleys are partially filled with sand, clay, and gravel and in this report such materials are referred to as valley fillings.

Aerial geology. Following is the stratigraphic section of rocks exposed in Johnson county. The nomenclature is in accordance with that of the Kansas Geological Survey.

Stratigraphy of Johnson County, Kansas

	Feet
Quaternary system:	
Recent series:	
Alluvium, stream deposits, gravel, sand, silt, clay, in the valley bottoms	0–100
Colluvium, fragmental talus deposits, humic soil, and clay	0–25
Residual soil, humic soil, clay, etc.	0–6
Recent and Pleistocene series:	
Loess, wind-blown material, fine-grained and locally sandy, buff to red	0–50
Pleistocene series:	
Kansas drift, glacial drift, till or water laid, erratics, local boulders, sand, clay	0–80
Unconformity.	
Tertiary ? system:	
Local, high terrace gravels	0–3
Unconformity.	

1. Published with the permission of Mr. Ogden S. Jones, supervising geologist, Kansas Emergency Relief Commission.

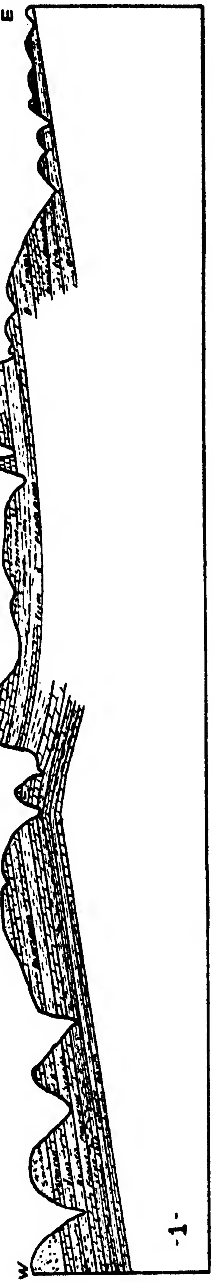


FIG. 1. Generalized geological cross section, west to east through the mi ddle part of Johnson county, Kansas. Vertical exaggeration, 40 times.

Pennsylvanian system:	
Virgil series:	
Douglas group:	
Stranger formation:	
Tonganoxie sandstone	30
Unconformity.	
Missouri series:	
Pedee group:	
Weston shale formation	?
Lansing group:	
Stanton limestone formation:	
Little Kaw limestone	3
Victory Junction shale	7
Olathe limestone	12
Eudora shale	6
Captain Creek limestone	5.5
Vilas shale formation	24
Plattsburg limestone formation:	
Spring Hill limestone	14
Hickory shale	.5
Merriam limestone	2
Kansas City group:	
Bonner Springs shale formation	25
Wyandotte limestone formation:	
Farley limestone:	
Limestone	5–10
Shale	0– 5
Limestone	10–28
Island Creek shale	1– 5
Argentine limestone	25
Quindaro shale	1– 5
Frisbie limestone	2
Lane shale formation	25
Iola limestone:	
Raytown limestone	6
Muncie Creek shale	3
Paola limestone	1
Chanute shale formation	12
Drum limestone	10
Quivira shale formation	5
Westerville limestone	10
Wea shale formation	10
Block limestone formation	6
Fontana shale formation	5–25
Bronson group:	
Dennis limestone formation:	
Winterset limestone	30
Stark shale	3
Canville limestone (probably not present)	

Galesburg shale formation	2
Swope limestone formation ·	
Bethany Falls limestone	24

Thicknesses given in the list above are in most cases approximate and will be found to vary from place to place. Descriptions of the individual rock layers are omitted, but those which are of importance in regard to water are described below.

Strata older and therefore lower than Farley limestone crop out only along the more deeply trenched streams in the eastern and northern part of the county. Stratigraphic units ranging in age from that of the Farley limestone up to the members of the Stanton formation occur along the slopes leading up to the more elevated areas over most of the county. These uplands are generally held by members of the Stanton formation. In the extreme western part of the county Tonganoxie sandstone occurs on the uplands. Chert or flint gravels, believed by the writers to be of Tertiary age, locally mantle the uplands. Glacial drift of Pleistocene age occurs as far south as the middle of township 14 south. Except in the extreme northern part of the county the thickness of glacial drift is negligible. Valley fillings are in part Pleistocene in age. Loess, wind-blown clay and fine sand, occurs in considerable thickness on the hills near Kansas river and elsewhere in thinner deposits which are difficult to differentiate from residual soil. Nearly all of the stream valleys are partly filled with alluvial and colluvial debris. Residual soil mantles the larger part of the county.

This report can be most effectively used with a map showing the areal geology of the county. Such a map has been prepared by Dr. N. D. Newell, for Bulletin 21, Kansas Geological Survey.

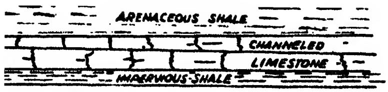
Drought situation in summer of 1934. When the water table, as the term is ordinarily understood, was at its normal level, wells ranging in depth up to and rarely exceeding 25 feet furnished most of the water supply for the rural communities. Farm wells fall into two classes: first, those which have been located for conveniences, that is, near the farmhouse or barn; second, those which have been located at the sites of hillside springs or seepages. The second group are in general shallow and may well include the springs themselves, some of which have been deepened. The wells of the first group are in general deeper, since it was necessary to dig them through the overlying soil to the aquifers. In the deeply filled valley of Kansas river in the northern part of the county the wells have been driven to a depth of about 35 feet or more into the alluvium. Before the emergency there were very few wells in the valley fillings of the smaller streams.

During the summer of 1934 a large percentage of the wells outside of Kansas river valley failed to supply sufficient water to satisfy the need. Many wells were dug into the Pennsylvanian strata. The newly dug wells with few exceptions produced but little water before the drought was broken, as little water remained in the aquifers. The situation can best be pictured as the drought having produced a great decrement in the amount of water in the aquifers rather than lowering the water table. It was observed that over a wide area a small amount of water was still present a few feet below the surface; the volume, however, was generally negligible. In former dry seasons the situation had been similar although less acute.

Only certain beds are aquifers in the sense that they yield large supplies of water. During the dry season under discussion the porous sandstone known as Tonganoxie sandstone, which occurs in the western part of the county, carried the greatest supply of water of any of the bedrock layers. Limestone, such as that found in the Plattsburg formation, which has been channeled through solution, is a suitable reservoir rock and is especially so where immediately overlain by an arenaceous shale. Deeply weathered, arenaceous shale seems to be very effective as the terrain of an area which may be designated as a catchment basin. Figure 2 shows conditions favorable for upland wells. It is apparent that the dip or slope of the bedrock as well as the slope of the ground is important in determining where the rock contains water and where to locate wells for best results. It is also important to understand that in limestone strata water occurs in "veins" or solution channels and that their presence cannot be definitely known in a buried rock. However, a study of the exposure will furnish information as to the nature of the buried strata. The presence of either permanent or wet-weather springs often offers a clue as to the presence of "veins." It is important and fortunate that long after springs had failed, good wells were found a short distance from the spring sites, under conditions shown in figure 2. Bedrock failed most commonly where conditions shown in figure 3 are present. In such areas dissection by rather closely spaced streams allowed the rocks to lose their water because of the prolonged drought.

In times of extremely dry weather one begins to look to the alluvial fillings of stream valleys for a supply of water. Observations in Johnson county brought out some seemingly important relations. During the summer of 1934 all valley fillings did not carry water and water was not present throughout all fillings even though it was found in some parts. The materials with which the streams have filled the valleys are directly related to the water-bearing capacity. In Johnson county the fillings, with the exception of that of Kansas river which is of sand and gravel of silicious and arkosic materials, are of clay or gravel of local derivation. The gravel is generally of limestone fragments, chert fragments, or sandstone fragments. In all cases observed the clay is in greatest abundance and the gravel is in lenticular bodies small in size. Clays were found to be nearly impervious, and gravels were looked for. It was found necessary to drill many test holes in order to learn the size of gravel lenses. Pumping of test holes was found advisable to learn rate of flow.

Observations of the valleys before testing threw some light on the possibilities. Valleys with deep fillings, but showing the conditions as in figure 7, offered poor prospects. It should be observed that the stream is on bedrock at the base of the filling. Where the tributary streams cut into material other than bedrock the outlook was better, but not encouraging. Conditions as shown in figure 7 were found to be present in many streams of the county and explain the paucity of water in many fillings. It should be noticed also that the valley walls are steep and of impervious materials. Conditions much more favorable are shown in figures 4 and 5. There the streams do not cut bedrock, but the filling is "sealed." Such conditions were found commonly in smaller streams or where the nearby uplands are of less resistant materials. Figure 6 shows a set of conditions which were found to be still more favorable.



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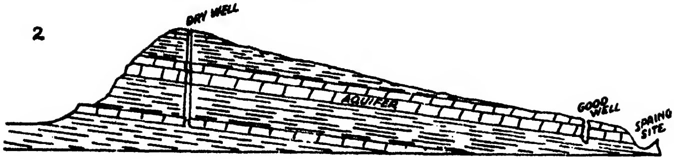

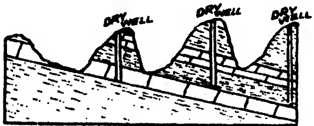

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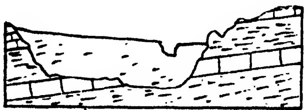

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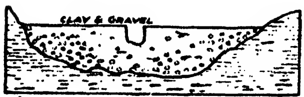

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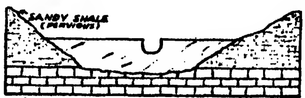

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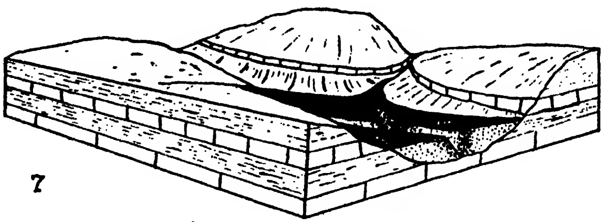

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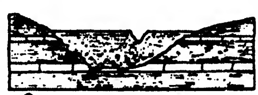

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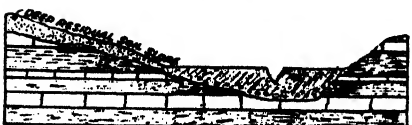

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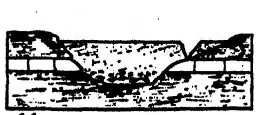

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FIG. 2. Geological conditions effecting upland wells.
FIG. 3. Geologic conditions unfavorable for wells.
FIGS. 4, 5, 6. Geologic conditions favorable for wells.
FIG. 7. A deeply filled valley showing poor prospects for water.
FIGS. 8, 9, 10, 11. Some conditions observed in str. am valleys in Johnson county, Kansas.

The filling is not drained through the stream cutting in bedrock, and the valley walls being of porous beds have acted as feeders to the filling. It is obvious that the inclination of the feeder beds is important. Experience seemed to indicate that conditions shown in figure 9 are still more favorable. Here a long slope, probably in the direction of dip of strata, of deeply weathered, arenaceous soil merges into the plain of the filling. Many streams not cutting bedrock in those places where they are near the middle of their valleys are doing so in places where they have meandered to the sides. Such conditions are shown in figures 10 and 11. In one case conditions as shown in figure 8 were found. A successful community well was dug into the deeper part of the filling. This set of conditions is unusual and requires for its explanation special geological conditions.

As indicated in the foregoing only a few of the rock layers are important aquifers during a long, dry season. Those which normally carry the most water are described below.

Argentine limestone. A persistent, thin-bedded limestone, about 25 feet thick, rather good aquifer in normal seasons, carrying water in fractures and in solution channels and along bedding plains. A few springs flowed a small amount during the drought.

Farley limestone. A brown, irregularly bedded limestone in two beds, generally lenticular, locally a good aquifer, carrying water in fissures near the outcrop. Water may be fed from sandy phase of the overlying Bonner Springs formation. Farley limestone supported several good wells throughout the summer.

Bonner Springs shale formation. A shale formation with lenticular beds of sandstone which is gray or brown. Brown sandstone was found to be a good aquifer.

Plattsburg limestone formation. Limestone beds, brown and earthy on the outcrop, but generally blue and crystalline where protected by overlying beds, massive beds in basal member, more thinly bedded above. Thickness is from 10 to 38 feet. A very good aquifer near the outcrop because of numerous joints and solution channels. Outcrop is marked by hundreds of wet or normal weather springs and seepages. A great many wells are supported by Plattsburg limestone. Many new ones were dug into it during the drought, but only a very few were successful then.

Vilas shale formation. An arenaceous, argillaceous shale and sandstone formation, ranging from dark-gray shale to light buff shaly sandstone. Thickness is variable. A good aquifer except in argillaceous phase. The arenaceous phase forms deeply weathered gentle slopes which carried a small amount of water during the summer. In nearly all cases the amount was not sufficient to warrant well location.

Eudora shale (Stanton formation). A shale member, mostly platy and carbonaceous, persistent in thickness and lithology. Thickness is about six feet. Carried a small amount of water along bedding and joint planes.

Olathe limestone. Thin, wavy bedded limestone, gray to dark in color, thickness about 17 feet. Olathe limestone is the sourse of a few wells which were fairly good during the summer. Water is carried along the bedding and fractures.

Victory Junction shale. Arenaceous and argillaceous shale. Contains lenses of sandstone which carried some water.

Tonganoxie sandstone (Stranger formation). Massive sandstone to sandy shale, mostly micaceous, fine grained and uniform, usually cross bedded, brown or gray in color, gray portion is more compact, brown portion carries more water. Gray portion where present is at base. A good aquifer where present in full thickness of about 30 feet. The Tonganoxie sandstone is the only exposed units of the Pennsylvanian system which carries enough water for even a small municipal supply. It supported many good wells during the drought. The city of Gardner obtained a large supply by running laterals from a large well.

.*Glacial drift* (Pleistocene). Glacial drift sufficiently thick to be an aquifer occurs in two small areas in the county. The more important area is in the lower part of the valley of Clear creek north and west of Zarah in sections 2, 10 and 12, of township 12 S., range 23 E. In this area water-laid drift of about 80 feet thickness partially fills the valley of Clear creek. A strong spring, flowing approximately 60 gallons a minute (during the drought), flows from lower portion. The drift is in a cross-bedded deposit of sand, pebbles, and boulders. Material from this deposit has long been quarried and used for road building. It is known as Holliday gravel. The second area is in the western part of DeSoto. The thickness is approximately 30 feet, and the deposit is of rather fine gravel and sand. The area is quite small, but the exact limits are unknown. Some half a dozen wells have been driven into it and they furnish large supplies of water. It is quite probable that water is fed into the sandy gravel by the sandy shale of the Vilas formation which dips locally to the northeast and into the area of the De Soto glacial deposit. Citizens of De Soto have at various times contemplated a municipal supply from this source. The exact geological conditions should be learned before proceeding.

Valley fillings. The alluvium of Kansas river valley was apparently saturated with water even during the severe dry season. Valley fillings of smaller streams in Johnson county are extremely variable both in lithologic character and structure. Water could only be detected during the drought through actual soundings. It could not be assumed that any certain filling carried water throughout its length. Abrupt changes in lithology are the rule rather than the exception. Tests were made where dry holes and holes having as much as three feet of water were within twenty feet of each other. In locating wells in valley fillings sufficient tests should be made to insure finding the maximum thickness of water-bearing strata. During the drought it was necessary to pump test holes repeatedly to learn the rate of flow.

After completion of field studies, Mr. Williams compiled a very detailed set of notes concerning the water conditions in each of the townships of the county. These notes were incorporated in a report which was sent to the office of the supervising geologist for the Kansas Emergency Relief Commission. They should be of value to anyone interested in local water conditions.

The writers were ably assisted in the field by Mr. Delos M. Douglas, a student at the University of Kansas. Valuable suggestions were received from Dr. K. K. Landes, of the Kansas Geological Survey. Many citizens of Johnson county were extremely helpful, and special thanks are due the county officials who coöperated to the fullest extent.

Kansas Mineral Industries During the Depression

KENNETH K. LANDES, University of Kansas, Lawrence, Kan.

The purpose of this study is to determine what effect the depression has had on the output of the eight leading mineral industries of Kansas. Production curves have been plotted for the years 1925 to 1932, inclusive. In most cases a distinct decline occurred following 1929. A second curve was plotted for each mineral industry to show the percentage of Kansas production in terms of the total U. S. production over the same period (Fig. 1). A study of this second curve shows whether Kansas gained, lost, or broke even in its competition with producers outside of the state. Three Kansas mineral industries (cement, clay products, and zinc) lost ground between 1929 and 1932, while four (natural gas, coal, salt, and gypsum) improved their relative position, and one, petroleum, practically broke even.

Petroleum and natural gas differ from many of the other mineral resources in that their production figures depend to a considerable extent upon the discovery of new fields. The discovery of the prolific East Texas oil field in October, 1930, coupled with a lesser demand due to the depression, lowered the price of oil to such an extent that there was little initiative for developing new fields in Kansas, or anywhere else. However, by 1932 it became necessary to develop new supplies and the search for oil in that year and since has been very successful so that Kansas has maintained its position as an oil-producing state. The discovery of new and large gas fields in Kansas has caused both the total production and the percentage of the United States production to increase in recent years.

The production of coal in Kansas declined considerably from 1925 to 1931. However, during 1932 Kansas produced practically as much coal as during 1931. At the same time the total production for the country declined, consequently Kansas bettered its position in terms of percentage, as shown by the unlabeled curve in figure 1. The reason for this is that the operators in southeastern Kansas so improved their operating efficiency that they were able to compete with Arkansas and Illinois producers.

Kansas contains enough salt to last the entire United States one half million years. But Michigan and New York state mines lie closer to the large markets so but an insignificant percentage of the Kansas reserve is removed each year. Although salt production fell off between 1929 and 1932 the percentage of the country's salt produced by Kansas increased considerably.

Statistics are not available for gypsum in Kansas between 1929 and 1931. The production in 1932 was less than that in 1928, but the percentage produced by Kansas increased from about 2½ to nearly 4 during that period.

The depression was felt very severely by mineral producers who sell to the building industries. Kansas production in both cement and clay products suffered a sharp decline during the depression years. Furthermore, the percentage likewise declined sharply, showing that these mineral industries were affected much more in Kansas than in the country as a whole.

The demand for zinc (as for other metals) fell off during the depression years and in consequence production likewise declined. Kansas steadily lost ground as a zinc producer during the years covered by this study. At one time the second zinc-producing state, Kansas now occupies fourth place.

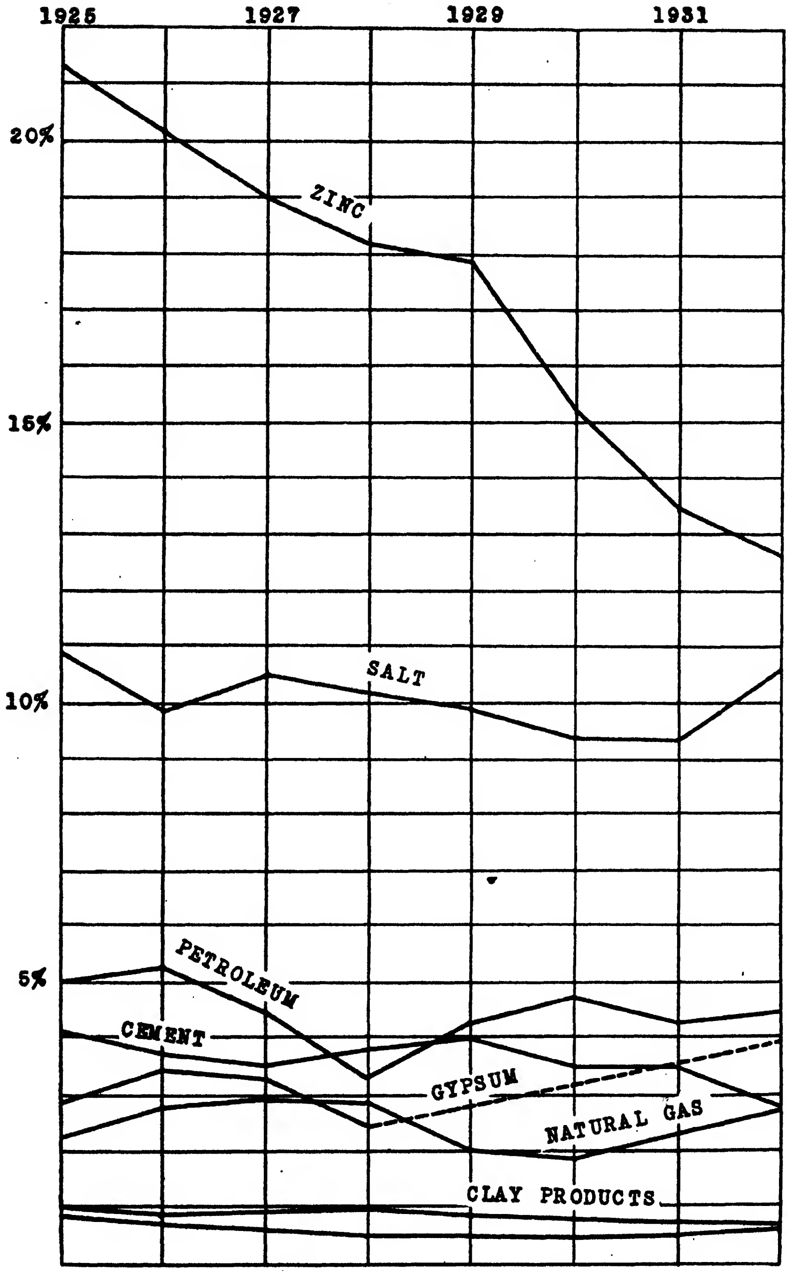

FIG. 1. Curves showing Kansas percentage of total United States production in eight mineral industries from 1925 to 1932.

Fluctuation of the Water Table in the Glaciated Part of Kansas*

WALTER H. SCHOEWE, University of Kansas, Lawrence, Kan.

The general deficiency of precipitation in Kansas during four out of the five last years was brought to a climax by the unusual drought of the summer of 1934. It resulted in the lowering of the water table to the extent that thousands of wells went dry, ponds evaporated, springs disappeared, and streams ceased to flow. The situation became so acute that the water supply of many cities, towns, and villages was greatly reduced, in some cases by more than 50 percent. In most communities the use of water was restricted. Watering of lawns and gardens, use of shower baths in schools, washing of cars, and the like were prohibited. At other places, the supply of water was rationed to the water consumers at a certain number of gallons per day. All means were employed to conserve the water resources to the fullest extent. This was especially true in the cities, towns, and villages where the conservation of the water was primarily for the purpose of providing a reserve for fire protection. It was the writer's observation, however, that in the glaciated counties of northeastern Kansas no adequate supply of water was ever available to have combatted a fire of any consequence had one started, this in spite of the rigid water conservation program exercised by most communities. The water shortage in the rural districts was even more severe than in the urban communities. On the farms, wells went dry by the scores every day as the intense heat of the summer continued. At first farmers without water hauled their supplies from neighboring wells. Gradually, however, as these yielded less and less water and finally went dry, water had to be hauled from greater and greater distances. Hauling distances of three to five miles were common, and in some cases water was imported from as much as seven to fifteen miles. The general shortage of water was aggravated by the fact that due to the intense heat practically all vegetation burned up. For a period of over 50 days the daily maximum temperatures ranged between 100 and 115 degrees Fahrenheit. This intense heat was accompanied by severe hot winds. As a result of the burning up of the vegetation, food for cattle and livestock in general was essentially nonexistent, a condition making water a greater necessity than ever before. Observations revealed the fact that during the very hot days full-grown cattle, deprived of their normal supply of food, consumed per head on the average thirty gallons of water daily. To counteract the dried-up pastures, trees were felled at many places and the cattle allowed to eat the foliage of the fallen trees.

Although the scarcity of water was undoubtedly due directly to the lowering of the water table, other factors contributed to the water shortage. Of these, the following three were the most important: (1) many wells were too shallow, (2) many wells were too small and therefore lacked sufficient reservoir or storage capacity, and (3) too many people had no auxiliary water supplies, *i.e.*, they lacked cisterns or farmyard ponds. Other contributing factors were

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neglected, unconditioned or polluted wells and unimproved springs. The shallowness of many wells is probably best explained by the fact that when the wells were dug plenty of water was available at shallow depths and no account was made for any considerable fluctuation of the water table. The lowering of the water table from 4 to 10 feet was sufficient to put these wells out of service. A large number of the wells contained some water, but not sufficient to adequately provide for the needs of the well users. Too many of the wells had a diameter of three feet or less and that, together with insufficient depth, afforded no reservoir or storage capacity. In many cases, a sufficient amount of water would have collected in the wells during the night to have supplied the needs for the following day had the storage capacity been considerably greater. Wells with a diameter of 5 to 10 feet and a depth several feet below the present water level of the wells would have insured the necessary storage capacity, and thus would have solved the water problem for many a farmer. A good illustration of the need for greater storage capacity is demonstrated by the following case.

A farmer in Jackson county employed a man whose sole duty was to pump water out of a well into a tank. The daily yield of the well was sufficient to water seventeen head of cattle and several hogs. In order to get this water, it was necessary for the hired help to remain continually at or near the well. Three minutes' pumping was sufficient to pump the well dry. After a lapse of an hour sufficient water had collected again to be pumped. Another three minutes and the well was dry again. This procedure was kept up during the entire day. Between the three-minute pumping spells the hired man sought shade under a road culvert, lay on his back and enjoyed the thrills of an exciting detective story or else closed his eyes, probably dreaming of a cooler day. The well under consideration has an outside diameter of 4 feet to a depth of 14 feet and then extended downward for another 13 feet with an opening of only 6 inches. Less than a quarter of a mile down the same draw a community well was dug 15 feet in diameter and 32 feet deep. Seventeen feet of water stood in the well. The storage capacity of this well was, therefore, 22,531 gallons, an amount sufficient to satisfy the needs of at least 751 head of cattle per day. Since all of this water collected during the nighttime, the services of a hired hand were eliminated.

It was a surprising fact that farmyard ponds and house and barn cisterns were notably absent in the area investigated. Wherever they were found the water shortage was less acute than elsewhere and in most cases sufficient water was available for ordinary needs. What was perhaps still more surprising was the fact that the people did not take to the community farmyard ponds projects sponsored by the FERA and KERC. The usual comment was, "Why build farmyard ponds when there is no water to fill them?"

Among the minor contributing factors accounting for the water shortage may be mentioned wells whose waters were polluted and tasted and smelled bad. A number of wells with plenty of water were unfit for use because of the presence of a dead cat, rat, or other object at the bottom of the well. Such wells, as far as the writer's observations go, were never pumped dry, cleaned and purified.

The writer served as geologist in the employ of the Kansas Emergency Relief Committee (KERC) in connection with the water conservation program

of the Federal Emergency Relief Association (FERA) and was assigned to work and supervise the work in the glaciated or northeastern portion of the state. In all twelve men worked under the writer's supervision in the following six counties: Atchison, Brown, Doniphan, Jackson, Jefferson, and Nemaha. The work consisted chiefly of finding new water supplies for municipalities and for rural communities and in aiding individual farmers to locate new well sites. Over ninety projects were completed, and advice and help were given to hundreds of individual farmers in selecting new well sites. In addition to prospecting for water, mapping aquifers, putting down test holes, digging, boring and drilling community and municipal wells, and cleaning, enlarging, and improving springs, considerable effort was made to determine the fluctuation of the water table. Data were collected on all of the six counties assigned to the writer and were obtained from information supplied by hundreds of individuals regarding the depth to the water in their wells in normal years and during the summer of 1934. Numerous measurements to determine the actual depth to the water in the wells were made during the progress of this survey.

Most of the wells in northeastern Kansas derive their water supply from unconsolidated material, either in the form of till, joint clay or boulder clay or from valley fill, flood plain or stream alluvium. Bedrock wells were relatively few. Topographically the wells of this area may be classified as (1) flood-plain wells and (2) upland wells, the latter including all wells not actually located on the flood plain. The flood-plain wells derive their water from aquifers composed of stratified sand, gravel or silt, whereas the upland wells derive their water from unstratified glacial deposits or till, or from sand and gravel pockets or lenses incorporated within the till or else from beds of stratified sand and gravel deposited as outwash material within the drift sheet. The following two test hole logs are typical of the flood plain and upland types of wells within the glaciated portion of northeastern Kansas.

FLOOD-PLAIN WELL

Material	*Thickness, in feet*	*Depth, in feet*
Soil	8	*8
Clay, fine	17	25
Sand	3	28
Sand, coarse	3	31
Sand, coarse, red	2	33
Gravel, coarse, pebbles 3″-4″	1	34

Soapstone (26 feet of water).
SW¼ sec. 4, T. 3 S., R. 18 E., Town of Robinson.
Test hole No. 3. Site of community well.

* Water at 8 feet.

UPLAND WELL

Material	*Thickness, in feet*	*Depth, in feet*
Soil	3	3
Clay	2	5
Clay, yellow	10	15
Gumbo	16	31
Till	13	44
Sand	0½	44½
Till	5½	50
Till, sandy	7	*57
Boulder	2	59
Sand, gravel	1	60
Sand, red	6	66

Soapstone (13 feet 4 inches of water).
NW¼ sec. 19, T. 4 S., R. 18 E. Town of Everest.

* Water at 54 feet.

TABLE 1. Summary of the fluctuation of the water table in flood-plain and upland wells in the glaciated portion of Kansas

County.	Flood-plain wells.			Upland wells.		
	Number of wells.	Range in fluctuation, in feet.	Average fluctuation, in feet.	Average fluctuation, in feet.	Range in fluctuation, in feet.	Number of wells.
Atchison	12	0–11	3	7.36	0–35	64
Brown	4	3–6	4.5	10.55	3–30	11
Doniphan	12	3–7.5	5.08	9.2	4–17	5
Jackson	38	0–17	5.42	8.41	2–20	23
Jefferson	2	5–6	5.5	7.45	5–12	11
Nemaha	4	0–7	4	9.12	0–29	33

The data on hand (see Table 1) show that information was obtained on 221 wells, of which 74 were located on the flood plains and 147 on the uplands. The water table fluctuated on the average from 4 to 5.5 feet in the flood-plain aquifer and from 7.36 to 10.55 feet in the upland wells or till aquifers. This is as might be expected. The flood-plain aquifers are composed of stratified sands, silt and gravel and texturally are very porous; whereas the till is not only unstratified, but consists largely of tightly compacted clayey material in which are interbedded pebbles and boulders of various sizes and kinds. Movement of water in the till is very slow and the amount of water is usually very limited. Where the till is sandy or where it contains interbedded lenses or beds of stratified sands and gravels, water is more abundant and the movement is faster. A comparative study of the variation or range in the fluctuation of the water table in the two types of aquifers shows that there is considerably less variation in the flood-plain wells than in the upland wells. The data suggest that the flood-plain aquifers are more nearly alike texturally, whereas the upland aquifers are texturally very unlike. The practical significance of this data is, therefore, that prospecting for water on the uplands or in the till is less dependable than on the flood-plains. Since the texture of the till varies greatly from place to place, the presence of water in one upland well does not necessarily insure an equal amount of variation of the water table nor the same depth to the water in a neighboring well. Successful flood-plain wells, on the other hand, may be located, depth to water ascertained, water-table fluctuation determined, and water capacity of well computed with a fair degree of safety and with certainty from a study of a few other flood-plain wells already in existence.

Some Effects of Experimental Diets Upon the Vitamin C Content of Certain Organs of the Guinea Pig (*Cavia cobaya*)*

ISABELLE GILLUM and M. M. KRAMER

During the course of experiments conducted with guinea pigs (1) the animals have been fed the widely used Sherman, LaMer, and Campbell (2) vitamin C-free diet, with and without supplements to add vitamin C. A number of the animals used in the study of reproduction and ovarian changes received daily measured portions of orange juice as a standard supplement providing vitamin C. Various workers have found that 3 c.c. of orange juice per 300 grams of body weight will protect the animal from scurvy, whether determined by the long-time 90-day tests or by the experiments of shorter duration in which changes in the teeth are studied. Some workers have reported satisfactory growth as a result of feeding this protective dose of orange juice.

In these experiments cited above (1) the nonpregnant female guinea pigs receiving 3 c.c. of orange juice grew at a subnormal rate and those receiving 5 c.c. were less than 10 percent underweight when killed. Pregnancies were not easy to secure even with those fed 5 c.c. of orange juice. All female guinea pigs receiving the standard diet, together with 3 or 5 c.c. of orange juice, failed to give birth to living young. Abortions or resorptions occurred in all the pregnant animals. This was true whether pregnancy had begun before the animals were placed on the experimental diet or whether the females became pregnant during the experiment.

These findings are in line with ideas now emphasized in various fields of nutrition, namely, that a wide margin must be allowed between the amount which must be fed as a protective dose and the amount which should be provided to secure a state of optimum well-being. Bessey and King (3) have shown that diets deficient in vitamin C leave the organs of the guinea pig nearly devoid of vitamin C, while a normal diet insures the presence of vitamin C in the organs. It therefore seemed desirable to study further the effects of supplements carrying vitamin C at levels above the minimum protective portion.

Animals used in the present series of investigations were born in the laboratory of mothers fed the standard vitamin C-free diet plus green food ad libitum. When young were born, the diet of the mother was changed, orange juice being substituted for the green food in daily amounts of 10 c.c. per 300 grams of body weight. Filter paper was fed for roughage. The young remained with the mothers, but received individual daily supplements of 5, 10, or 20 c.c. of orange juice per 300 grams of body weight. At the age of 8 weeks the young were killed and tissues taken for examination.

The direct titration method of Bessey and King (3) was used for estimating the vitamin C content of tissues, employing the oxidation, reduction

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* Contribution No. 46, Department of Home Economics, Kansas Agricultural Experiment Station.

indicator, 2.6-dichlorophenolindophenol which has come into extensive use for the direct titration of vitamin C. In spite of complications connected with this and other methods of vitamin C titration, the titration methods are of importance because they permit of rapid estimation when the sample cannot be studied conveniently otherwise. The dye was prepared, standardized daily and used according to the suggestions of Bessey and King (3). The fresh animal tissues were weighed, ground and extracted with 8 percent trichloracetic acid and the extracts were titrated rapidly.

Results obtained were calculated in terms of milligrams of ascorbic acid (vitamin C) per gram of tissue and per organ. Figures are now available concerning certain tissues from 14 animals and are presented for comparison with data of Bessey and King (3) as follows:

Supplement, orange juice.	Number of animals.	Kidneys.		Heart.		Adrenals.	
		Total in organs.	Per gm.	Total in organs.	Per gm.	Total in organs.	Per gm.
		mg.	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*
5 c. c.	6	0.22	0.09	0.05	0.05	0.06	0.38
10 c. c.	5	0.43	0.13	0.07	0.07	0.06	0.49
20 c. c.	3	0.48	0.14	0.05	0.05	0.13	0.84
Bessey and King's figures for: Normal adults	....	....	0.09	....	0.09	....	0.75
Adults depleted 15 days	....	....	0.04	....	0.03	....	0.10

The kidneys showed greater ascorbic acid content for the animals receiving larger amounts of orange juice, whether the comparisons were based upon the content of the organs or the content of a gram of tissue. The kidneys of animals receiving 5 c. c. orange juice contained the same amount of ascorbic acid as did the normal animals used by Bessey and King.

Studies of the hearts of these animals showed that ascorbic acid was present in all cases. The supplements used apparently caused little variation in the ascorbic acid content of the heart. The ascorbic acid content per gram of organ for these young animals was intermediate between the figures reported by Bessey and King for adult animals.

The last organ here reported is the adrenal, the tissue recognized as important in this regard and reported by Bessey and King to be far richest in vitamin C. Their figure was 0.75 mg. per gram for the organ of the normal adult. The average for the young animals of this series on the smallest amount of orange juice, the 5 c. c. portion, was a little over half the figure found by Bessey and King, namely 0.38 mg. per gram. The adrenals of the animals receiving the 10 c. c. portion showed an increase and the adrenals of the animals receiving 20 c. c. gave an average for the few animals available slightly higher than that reported by Bessey and King.

Several authors have emphasized the fact that ascorbic acid is present in the tissue for some special function, as to maintain the reduction potential, and that the supply in the adrenal is not to be regarded as a reserve store.

No animal of the present series had as much as 1 mg. of ascorbic acid in the adrenals, while 5 c.c. of orange juice, the smallest daily portion used in this series, carries about 3 mg. It is suggested, however, that the ascorbic acid content of these tissues, particularly of the adrenal, may be increased with increased well-being of the young animals receiving supplements above the recognized protective portion. The experiments of which this is a preliminary report are being continued.

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A Preliminary Study of the Vitamin A Content of Milk and Colostrum*

BERNICE L. KUNERTH, M. M. KRAMER and W. H. RIDDELL, Kansas Agricultural Experiment Station, Manhattan, Kan.

Vitamin A studies of milk and colostrum of different breeds of dairy cattle are being conducted at the Kansas State College Agricultural Experiment Station. The initial series of experiments involved feeding rats samples of colostrum (the first milk drawn after the cow freshens) and normal milk from cow H, a Holstein, and cow G, a Guernsey. The cattle had been for some months on winter feed consisting of alfalfa, silage, and grain mixture at the time the samples were collected.

Albino rats weighing from 38 to 40 grams were transferred from the stock diet to the vitamin A-free diet (Sherman and Munsell[1]) and depleted of their body reserve of the vitamin. Depletion is indicated by cessation of growth and is frequently accompanied by the development of sore eyes. After the fore period, the rats were divided into two groups in which there were equal numbers of males and females. The average initial weight for the different groups was approximately 91 grams (90.75-91.25).

The single feeding method recently developed by Sherman and Todhunter was used to test the vitamin A content of the milk and colostrum. Negative controls receiving the vitamin A-free diet only and positive controls receiving carotene in single feedings were maintained throughout the experiment. According to the procedure of the single feeding method, the rats, after becoming depleted of vitamin A, were given only one feeding of the material to be tested. The rats were weighed every week and their composite growth curves were plotted. During the first weeks after the single feeding, their composite growth curve rose rapidly, continued to a maximum and fell until the animals died. The growth curve is represented by a solid line only as long as all the animals of the group survive. The shape of the curve is dependent on the quantity of vitamin A in the original feeding. The amount of gain and the survival days are proportional to the amount of vitamin A fed at the beginning. For accurate comparisons the curves are plotted carefully on standard paper and the areas measured with a planimeter as described by Sherman and Todhunter.[2] According to this method the weight of the negative control group at the end of the first week was used to determine a satisfactory base line.

The colostrum from cow H was fed in two amounts, 1 gram and 2 grams. The larger portion seemed to be an advantageous amount to feed and the colostrum from cow G was therefore fed in 2 gram quantities. Milk was fed in 20-gram portions. Both milk and colostrum fed in these quantities produced decided increases in growth and survival over that observed in the negative controls.

* Contribution No. 44, Department of Home Economics, and Contribution No. 99, Department of Dairy Husbandry.

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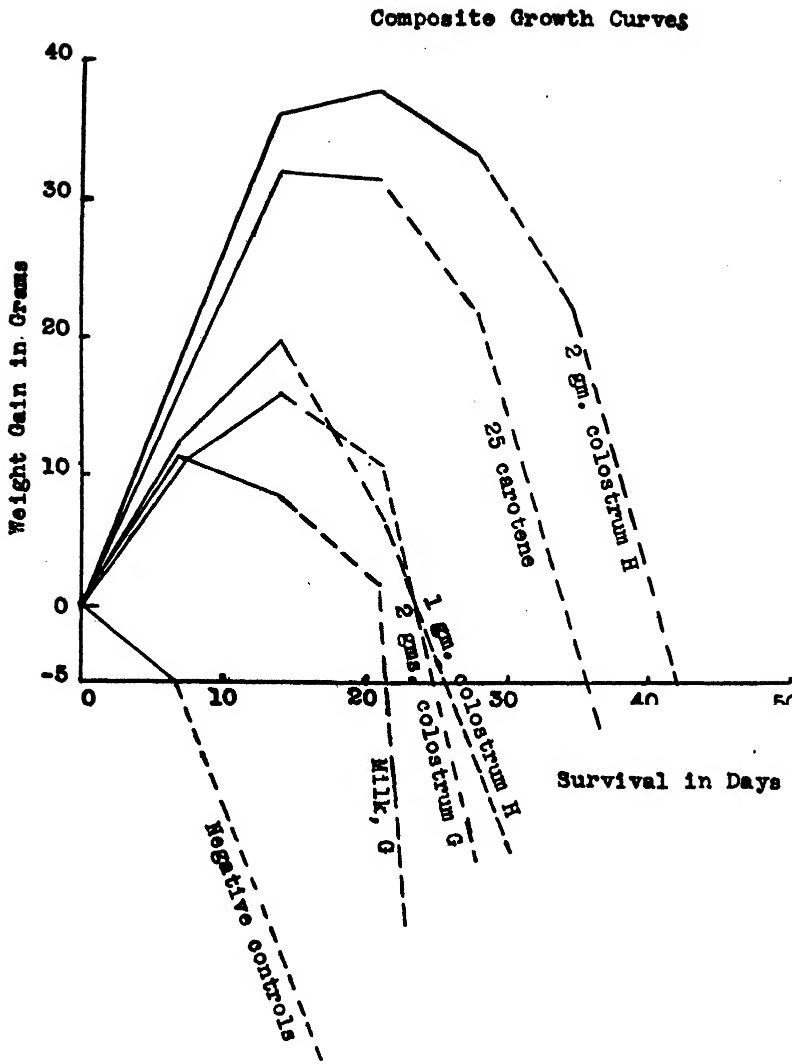


	Number rats in group.	Survival.	Areas under curves.
		Days.	*Sq. in.*
Negative controls	12	17.6	....
Positive controls	8	37.4	8.6
Colostrum, cow H, 1 gm	8	30.9	3.6
Colostrum, cow H, 2 gms	10	42.0	12.2
Colostrum, cow G, 2 gms	8	28.2	3.4
Milk, cow G, 20 gms	6	23.5	2.4

DISCUSSION

The response of the control animals was satisfactory. The negative group lost weight and died in the usual way. The positive control group received 28 gamma (28 millionths of a gram) of standard carotene, supplied by the Bureau of Chemistry and Soils, United States Department of Agriculture.

The curves for the animals receiving a single feeding of 20 grams of milk from cow G and the area under it is similar to that for 2 grams of colostrum from the same cow. This sample of colostrum is more than 10 times as rich in vitamin A as the normal milk produced by the same animal. According to the curve of the rats receiving a single feeding of 1 gram of colostrum from cow H, this sample of colostrum seems to be about twice as rich in vitamin A as the sample of colostrum from cow G. Variation in the vitamin A content of the colostrum of different cows may be attributed to any one of a number of different factors, several of which are under investigation.

The data from rats fed colostrum from cow H at a 2-gram level compared favorably with the positive control. This amount of the colostrum therefore contains at least as much vitamin A as that represented by 28 gamma of carotene.

The young calf is born without a reserve of vitamin A and it is therefore important that it receive the colostrum since colostrum is a rich source of this vitamin.

The Movements and Forces in Tornadoes

JOHN T. COPLEY, Olathe, Kan.

It has been my privilege to observe several tornadoes at close range and also to examine the effects of others. In the early days in Kansas little whirlwinds would appear over bare or scantily covered ground and move forward for short distances and then disappear as quickly as they appeared. Sometimes several would apppear within a small area and rise with sufficient force to remove our hats and even move heavier objects on the ground. The observation of these led to the more extensive study of tornadoes.

Tornadoes are often miscalled cyclones because both are formed under similar conditions and are governed by the same natural laws. The tropical ocean cyclones with which we are most familiar have a swiftly whirling wind around a calm center sometimes hundreds of miles in diameter. They move forward for days along the warm ocean currents such as the Gulf stream and the Japan stream. Tornadoes form on the oceans and on the land. The vortices at the surface of the water and the land are sometimes only a few feet in diameter. They move forward almost always in a northeasterly or easterly course. Several may appear in different places on the same day. Sometimes one will follow another in the same path within a few hours. Ten years ago one moved over Kentucky into Indiana and united with the great one which moved out of Missouri through Illinois into Indiana. Three separate tornadoes united to form the one which did so much damage east of Perry, Kan., many years ago. I watched one approaching the town of Oak Hill, Kan. When within less than a mile it divided into two tornadoes. The larger one moved north, the other one moved eastward within less than a quarter of a mile of me. When mud and water began to fall on me I sought shelter.

Tornadoes form on unseasonably warm days when there are no atmospheric currents to disturb the overheated air next to the surface. When a heavy stratum of cold air blows over this overheated air the warm air will rise into the cold air just as bubbles of air rise through water. The warm air will make an opening into the cold stratum and rise until its temperature is reduced to that of the surrounding atmosphere. The warm air beneath will flow from all directions toward this opening and whirl round it just as water will whirl round an opening in the bottom of a vessel. The centrifugal force of the whirling water will keep it from flowing down through the center of the opening and if this is large enough one may thrust his finger through the center without touching the water. In like manner the centrifugal force of the whirling wind will make a partial vacuum in the center of the ascending air. As the earth rotates on its axis the atmosphere rotates with it and the nearer it is to the equator the more rapid the rotation. When a south wind blows toward a tornado this eastward rotation of the atmosphere will draw the wind a little to the east of the tornado. The slower velocity eastward of a north wind will cause it to fall a little to the west of a tornado. In the northern hemisphere these winds will cause the whirl to rotate in the opposite direction from that of the hands of a clock. In the southern hemisphere this whirling movement will rotate in the direction of the hands of a clock.

When a tornado passes over a building if the partial vacuum is large enough it will reduce the atmospheric pressure on the outside, and the normal pressure within, if it has no other opening to release it, will force one or more of the walls outward. Closet doors, trunk lids and other coverings may be forced open also. The caps on sealed cans of fruit have been forced off by the pressure of the air within them without moving the cans. The front wall of a store building in Oak Hill, Kan., was forced outward. The paper shade on a lamp in the room above was not disturbed. If a building has only one room the four walls may all give way at once. The larger the wall the more likely it will give way. For this reason one is safer in a small house if it is properly constructed than in a larger one. Five persons were killed in a tornado in Omaha some years ago. They all sought safety in a large steel garage. If the doors and windows had been open the garage might have stood the storm. The Presbyterian parsonage and church at Clinton, Kan., only fifty feet apart, were directly in the path of a tornado. The windows in the parsonage were forced outward, but the house stood. The four walls of the church were all forced outward. The downward pressure of the air within the church held the furniture and the floor on the foundation.

The body of a tree will expand in the partial vacuum of a tornado. Part of the air within will force its way out through the more or less porous wood and perhaps enlarge some of the pores as its escapes. When the partial vacuum is displaced by the denser atmosphere air will be forced in through these open pores before the wood has time to contract. Straws and other small particles may be forced into the pores with the inflowing air. It seems impossible that a strong wind could drive straws into the solid body of a tree. Such a wind would leave no trace of the straws on the outside. I saw trees, after tornadoes had passed over them, stripped of their bark, yet the branches were unbroken. The bark was forced off by the expansion of the wood and the pressure of the air within. The body and skin of a chicken will expand in the partial vacuum. The feathers will loosen and could be removed easily. No chicken could stand against a wind that is strong enough to blow the feathers off. In high altitudes some persons have found the blood oozing from the inner membranes of their ears and noses.

The first appearance of a tornado may be the whirling cloud in the upper atmosphere, caused by the condensation of the excess moisture in the warmer air. A tornado begins with the whirling wind around the opening into the cold stratum of air. It may move some distance before it descends to the ground. One evening at nine o'clock the air in my room became perceptibly warmer. I went out expecting to see a storm approaching. Suddenly, for a moment only, the air became still warmer. I knew then that a tornado had passed over me. It came down to the tops of trees about three miles northeast of me, and five miles beyond it completely wrecked a house except the floor, which was left on its foundation. A little farther on it swerved sharply to the right for a few rods and then went on its course. Some tornadoes descend and ascend several times. Others remain in the air. I traced a tornado in Topeka for over a mile by the broken tops of tall trees. It passed over many buildings and uprooted a few tall trees but left no trace on the ground. It must have had an educational turn of mind, for it began near Washburn College and ended near Bethany College.

A few years ago after waiting some time for "more favorable weather" ten airplanes were started in a race from San Francisco to Honolulu. Only one reached Honolulu. Army planes were sent out to search for the missing nine. Two of the army planes sent forth S. O. S. calls reporting that they were in "tail spins." No trace of these eleven planes could be found. A few weeks ago two experienced pilots, after waiting for "more favorable weather," started from San Francisco to map out a mail route to Australia by way of Honolulu. Their plane was equipped with the most modern improvements and up-to-date safety devices, including pontoon wings for safe landings on the ocean. It, too, disappeared leaving no trace of its whereabouts. Is it not possible that the "more favorable weather" which they waited for was more favorable for the formation of several tornadoes or strong currents of rarified air? If an airplane should fly into the rarified air in a tornado the weight of the plane adjusted to the denser atmosphere without would cause it to drop suddenly. The motor and other metal parts of the plane would cause it to descend in a tail spin in which it might be impossible to right the plane, and the accelerated speed of the descent would send it far into the ocean. Are not some of the tail spins above land caused by ascending currents of rarified air? With these suggestions I will close.

The Water Supply of the Upper Neosho River Basin and the Laws of Rainfall

LYMAN C. WOOSTER, Kansas State Teachers College, Emporia, Kan.

During the drought of 1934 the supply of water in the Upper Neosho river basin was rapidly approaching exhaustion when the rain of November 17 and 18, 1934, filled the reservoirs of Emporia and Council Grove and the wells of the farmers in the valley. Everybody at once was interested in the cause of this rainfall.

The Neosho river basin, like many other basins in central Kansas, lies in an amphitheater eroded from the Flint Hills upland by the river and its tributaries and covers about one thousand square miles of surface. The margins of all these basins include some of the best pasture lands of Kansas and produce the excellent Flint Hills beef. The bottom lands grow great crops of corn, alfalfa, oats and wheat.

The slope of this basin, where more than 30,000 people make their homes, is indicated by the elevations of its chief towns: White City, 1,469 feet above the sea level; Council Grove, 1,234; Dunlap, 1,180; Americus, 1,154, and Emporia, 1,134.

The uncertainties in the weather—drought and hot winds, and floods—make a study of the weather very desirable that the people may try to prevent the damage done.

Printing of wire-photo Weather Maps from Washington in the larger daily papers, as the Kansas City Star-Times, has also attracted special attention to the weather.

From records kept during a long series of years it has been learned that the annual rainfall of eastern Kansas has averaged thirty inches, with many ups and downs. There have been many floods during the past seventy years and many hot and dry summers. The floods not only carry away priceless water, but they also take domestic animals and valuable crops. More seriously still, they carry off much of the essential elements of the soil and thus deplete farm fertility. The hot, dry winds injure the pastures and ruin many crops.

The problems to be solved, then, include the prevention of soil erosion, the holding back of flood waters in ponds, lakes and reservoirs and the cooling and moistening of the hot, dry winds by water evaporation and transpiration from green crops and forests.

RAINFALL

The moisture that gives Kansas, for example, a large part of its rainwater comes from the Gulf of Mexico, brought in by southerly winds sliding over cold, northerly winds. This was demonstrated at Emporia July 5, 1934, when a strong south wind could be seen blowing clouds to the northward on top of a cold wind from the north, beneath. The rainfall was 1.37 inches. Western Kansas is not north of the Gulf and, therefore, cannot expect an average of more than ten or fifteen inches of water each year.

THE PLANETARY WINDS AND THEIR GENERAL EFFECT ON RAINFALL AND DROUGHT

The northeast and southeast trade-wind belts meet near the heat equator in a belt of calms known as the doldrums and rise into the upper atmosphere. Cooling as the air rises, much of the moisture is precipitated in heavy rains. Part of this air flows northward in a sheet directly over the trade-wind belt, but in the opposite direction. Somewhere near the Tropic of Cancer this cold upper current meets a cold upper current from the north and the two descend to the earth.

Becoming warmer as they descend they are very greedy for water. The parts over the oceans are readily satisfied, but not so the parts over the land, and they rob it of needed water. As a consequence the deserts in the Northern Hemisphere are traversed by the Tropic of Cancer. It is very fortunate for the great Mississippi basin that the Gulf of Mexico lies in a depression of the earth's surface. It would otherwise be a second Sahara Desert, for the Tropic of Cancer traverses its entire length.

From this mix-up of currents at the Tropic of Cancer, known as the Horse Latitude of Calms, part of the air returns at the surface to the equator as the trade winds and part passes into the temperate zone as the prevailing westerlies.

FERRELL'S LAW OF WINDS AND CYCLONIC STORMS

The earth's velocity of rotation diminishes from one thousand miles per hour to the eastward at the equator to zero at the poles; as a consequence, air having the velocity of the earth on moving north gains on the earth and tends to go northeast, and air moving south loses on the earth and goes southwest, in both cases turning to the right.

Therefore, when currents of air from the north and the south meet, each turns somewhat to the right and they produce an counterclockwise rotary movement as in cyclones and tornadoes. When currents of air separate, part going north and part south, each turns to the right, producing a clockwise rotation as in anticyclones.

According to Charles L. Mitchell and Willis E. Hurd of the United States Weather Bureau, Washington, D. C., the primary sources of our cyclones lie four or five hundred miles south of the Tropic of Cancer in the West Indies, East Indies and in the West Pacific Ocean west of Mexico. No one has seen the cyclones start their intense whirls, but all believe that they are caused by conflicting air currents.

There are many high mountains and extinct volcanoes in these three regions. The writer suggests that the trade winds and the higher southwest winds just above them flowing in the opposite direction may start a whirl about some of these high mountains.

In the *National Geographic Magazine* for October, 1934, Capt. John H. Craige, of the Marine Corps, says, in describing an afternoon thunder storm near Port au Prince, Haiti, about 400 miles south of the Tropic of Cancer—and in personal letters: "On the steep sides of a mountain black masses of clouds whirled with frightful velocity, going from east to west . . ." "At length with a blinding flash the storm burst upon us." "An icy wind rushed down the 8,000-foot mountainside." This might well be taken as the descrip-

tion of the beginning of a cyclone, the icy wind being from the upper air current. This valley is called the mother of Hurricanes.

If for any reason the great southwest antitrade currents in the upper air meet the cold upper northeast currents higher than usual above the Tropic of Cancer, so high that the average barometric pressure is greatly increased, it has been observed that the number of hurricanes in spring and early summer is greatly diminished, and vice versa. The explanation may lie in the lifting of the southwest currents above the tops of the mountains in the one case and depressing them in the other.

THE BIRTHPLACES OF THE CYCLONES

I. From somewhere in the West Indies come the cyclones that water the Atlantic coast states and occasionally those that border the Gulf of Mexico. Most of these storms are of moderate intensity, but at times one comes of such high intensity that it destroys life and property in Florida and in the islands to the eastward. These last are known as West India hurricanes.

It is probable that some of these cyclones cross the Atlantic and bring rains to Europe and northern Asia, and may even cross the Pacific and enter the United States. Charles L. Mitchell, of the United States Weather Bureau, says that some of the cyclones that cross Siberia may join those of Group II and cross the Pacific. The length of the journey is not objectionable, for Mr. Mitchell describes one cyclone that more than circled the earth.

The cyclones of Group I are of high importance and there are plenty of extinct volcanoes in the West Indies to serve as starters.

II. The cyclones of this group are the favorite storms of the members of the weather service at Washington, for they are quite regular in their habits. After they have crossed the Pacific ocean they enter the United States over Oregon and Washington, make room for cold anticyclones and thus bring rain to the northern and central states.

They originate, according to Charles L. Mitchell of the Weather Bureau, somewhere south of Japan and west of the Philippine Islands. There are plenty of extinct volcanoes about the China Sea to serve as nuclei to cyclonic whirls. Here again some of the cyclones make such a vigorous business of whirling that they destroy many lives and much property—these are the Typhoons.

After crossing the Northern Pacific the cyclones of Group II enter the United States somewhat subdued in temperature and bring only a moderate amount of water for rain. When they encounter the cold mountains of the Coast Range, the Sierras and the Rocky Mountains part of the moisture they carry is condensed and precipitated on the Pacific states. It requires the cold of an anticyclone from the Arctic regions and the warm, moist winds from the Gulf of Mexico to make these storms give rains to the Great Plains states and those east. Moving from a colder to a warmer latitude is also against their rain-producing qualities.

III. The cyclones of the third set enter the United States over Southern California, Arizona and Mexico, coming from somewhere west of Mexico. As these cyclones possess a high temperature, they carry a great quantity of water and require only a moderate amount of cold to cause the storm to drop the water in heavy rains, very frequently bringing floods. The country about

Los Angeles is often under water from these cyclones and the floods of the Neosho and Cottonwood valleys are probably caused by these storms. The writer remembers two cases in which heavy rains were brought to the Neosho valley by these cyclones. In these instances, however, the southern cyclone was joined with a northern cyclone by a trough of low pressure. Like many others he had not given these southern cyclones their true value till the drought of 1934 forced him to study them.

On November 17, 1934, a heavy rain saved the Neosho Valley from a water famine. The reservoirs at Emporia and Council Grove were nearly empty and many wells on the farms were dry, when a rain of 3.37 inches on the northwestern side of the valley-basin filled the wells and reservoirs with a six-months supply of water. This cyclone came from the southwest joined by a trough with a smaller cyclone of the northern sort. Already this spring floods at Los Angeles, rains in Oklahoma and Kansas, floods in the Mississippi valley and two sets of tornadoes have attended the passage of the southwestern cyclones.

The opening of the Panama canal has made it necessary for the Weather Bureau at Washington to make a special study of the weather conditions along the coasts of Central America and Mexico. Willis E. Hurd, of our Bureau, has published an excellent preliminary report of the storms that may be expected in that region. Among the sources of cyclones Mr. Hurd lists the Revillagigedo (Rā-vēl-yä-hē-hā-tho) Islands southwest of the southern end of Lower California, having nearly the same latitude as Haiti. Socarro, the largest island of the group, has an extinct volcano, 3,660 feet high, that might well be one source of these cyclones from the southwest. Mr. Hurd says that Second Officer, David Polowe, warns shippers of the dangerous character of the cyclones that come from the direction of the Revillagigedo Islands.

WHAT MAKES IT RAIN?

First: The capacity of the atmosphere for holding water-vapor is greatly increased with higher temperatures. This is shown in the following table which gives the capacity of a cubic foot of space in grains when saturated at the four temperatures, Fahrenheit:

32°, about two grains	80°, about eleven grains
50°, about four grains	100°, about twenty grains

This table shows why the temperature must be reduced to make it rain or snow. If the temperature be reduced much and suddenly the phenomenon known as a cloudburst results.

Second: When warm, moist air flows against a cold mountain, when it rises into the cold upper regions of space, or when it mingles with cold air of an anticyclone it may rain or snow. The Dry Tortugas out in the Gulf of Mexico have little rain because no cold reaches them.

WHAT ARE CYCLONES, ANTICYCLONES, TORNADOES AND BLIZZARDS?

Cyclones are warm storms that rotate counterclockwise and may be a thousand miles in diameter. They press lightly on the earth and hence are sometimes called lows—low barometer.

Anticyclones are cold storms that come in the Northern Hemisphere from

the arctic regions and are sometimes called highs, for they press heavily on the earth. They rotate clockwise.

Remembering that the cyclone is a great body of warm air flowing in from all directions, flowing spirally upward and rotating anticlockwise, and that the anticyclone is a great body of cold air flowing spirally downward and rotating clockwise, it will be seen that the air on the nearer sides of these two great bodies is moving in the same direction and that much of the air of the high may join in the whirl of the low, usually causing rain.

Not infrequently in Kansas and in the states to the south and east a large body of the cold air of the high overrides a mass of the warm, light air of the low in its southeastern quarter. At a favorable opportunity the moist, hot air may make a passageway up through the cold, heavy stratum above, and as it rushes up through the passage whirls vigorously anticlockwise. This is a tornado.

Should the cold air of a vigorous high that follows northwest of a low flow into the northwest quarter of the latter, the arctic cold of the wind from the high converts the moisture of that part of the low into snow needles and the blizzard of the great plains comes once or many times each winter.

Tornadoes may be looked for in the South each spring, in Iowa and Wisconsin in midsummer and in the South again in the fall. Midway states get the twisters between times. Tornadoes usually travel to the northeast, depending somewhat on the topography.

All cyclones or lows and all anticyclones or highs travel eastward across the United States or northeastward along our eastern coast and leave over New England and the Gulf of St. Lawrence, many of them bound for Europe. In the wintertime they travel at the rate of 500 to 1,000 miles per day, but in the hot, dry summers of the West they may not go more than 50 or 60 miles each day. The lows draw in the hot, moist winds from the south, but not a drop of rain falls for weeks.

THE WEATHER VALUE OF PONDS, LAKES AND RESERVOIRS

Besides holding great quantities of water, invaluable for a myriad uses by plants, animals and man, the water modifies climate in a way not generally understood. When the hot winds of summer blow for weeks from the southwest without bringing a drop of rain, people wonder why the drought does not generally begin till after the wheat has ripened.

It has been estimated that green crops transpire five tons per acre of water each day of sunshine. With the wheat harvest this source of supply of water to moisten the air stops. The fields of alfalfa and the forests continue to transpire water to moisten the "hot" winds, but they take the water from the subsoil and the wells go dry and the rivers stop flowing. The subsoil must be given another source of supply and the "hot" winds must be moistened someway.

How can the evaporation of water from ponds, lakes and reservoirs make good the loss of transpiration from green crops? It does so in two ways. 1. Kansas air is usually very greedy for water and takes in one year from a free-water surface, 40 inches in depth in eastern Kansas and 50 inches in western Kansas (Salisbury's Physiography, page 567). 2. It takes 5½ times as much heat to change water into vapor without raising the temperature as

is necessary to raise the temperature of the same amount of water from that of freezing to that of boiling (A. W. Smith in Physics). All this shows why green crops, forests and open bodies of water cool and moisten the air and thus induce rain.

SOIL EROSION AND FLOODS

All have noted the fact that the run-off from a rainstorm is loaded with soil, but most people do not even estimate the amount of soil loss. At the United States Experiment Station at Bethel, Mo., where the slope averages less than 8 percent it was found that bare ground lost 22 tons of soil per acre from April 1 to December 1. The annual loss from corn land was 17 tons per acre, and from wheat was 7 tons. All this with less than average rainfall.

This loss of the best elements of the soil by the run-off can be largely prevented by horizontal plowing and by terracing. By building dams to hold the water back in ponds, lakes and reservoirs, the subsoil water is replenished and the soil kept on the farms where it belongs.

It is entirely probable that the floods that have visited the rivers of Kansas and of the south central states were caused in large part by the heavy rains brought by the cyclones from the southwest, just as the recent (1935) floods of Missouri and the states east and the tornadoes in Texas all attended one or more of these Mexican storms.

According to Miss Laura M. French, in her History of Emporia and Lyon County, the records show that there have been 24 floods in 72 years in the Neosho and Cottonwood river valleys, or an average of one flood-year each three years. One half of the floods have come in June, four in May and one each in January, April, August and November. The month was not given for the remaining floods.

Each inch of rain gives more than 113 tons of water to each acre of land. An annual rainfall of 15 inches in western Kansas, therefore, would give 1,700 tons of water to each acre of land in that part of the state; and a rainfall of 30 inches would give on the average 3,400 tons of water to each acre in eastern Kansas each year.

With horizontal plowing, with terracing of hillsides, with ponds on each farm, with a lake in each county and with several reservoirs for each city, Kansas receives enough water for all her needs with some to spare.

With millions of fires in homes, automobiles and factories warming up the lower strata of the earth's atmosphere in the United States and Canada where before man came was nothing but the cold surface of the earth and the heat from the bodies of animals, a warmer climate must be the result.

Inverse Processes of the Radioactive Beta-decay

(ABSTRACT)

R. L. DOLECEK, University of Kansas, Lawrence, Kan.

It is generally recognized that the beta-decay has, at least formally, to be treated as a double process in which in addition to the beta-electron a second particle of hypothetical character is emitted. It has not been possible, to date, to detect such a particle (neutrino).

As we know no other processes than the beta-transformation which involve the occurrence of a neutrino, safe conclusions regarding the possible manifestation of this particle must be based on the known mechanism of the beta-decay.

The probability of the occurrence of inverse processes in which an impinging neutrino is captured by a nucleus (simultaneous with the emission of an electron) has been investigated. The maximum cross section to be expected is of the order 10^{-44} cm^2 which occurs for neutrino energies of about fifty million electron volts. This cross section would permit a neutrino to travel through 10^{21} centimeters of lead. It is questionable, therefore, whether the assumption of the real existence of such a particle is of any material benefit.

A High-voltage Electrostatic Generator, Van de Graaff Type

D. C. JACKSON, Jr., and L. M. FARBER, University of Kansas, Lawrence, Kan.

INTRODUCTION

The Van de Graaff electrostatic generator was invented by Dr. Robert J. Van de Graaff, now of the department of physics at the Massachusetts Institute of Technology, primarily as a source of high voltage for nuclear investigations in the field of atomic physics. The machine is a single-terminal arrangement giving a direct-current output. The voltage produced by it is a smooth, steady potential free of ripples and pulsations. The current of the output is necessarily small, this disadvantage being inherent in the method of building up voltage by deposition of charge. The voltage regulation is great and hence the machine can be used only in work where the power is not an important factor but where high potential is necessary.

The efficiency of the generator with respect to the expenditure of power for the maintenance of voltage is many times greater than that of any other arrangement giving a direct current with even only an approximately steady value. Step-up transformers and condensers, which are the basis of the other unidirectional output arrangements, are increasingly inefficient as the voltages are increased, because the amount of power to supply leakage, corona, and charging currents becomes much greater. The maintenance of 10,000,000 volts at sixty cycles across two terminals requires the expenditure of 10,000 kilovolt-amperes to supply the leakage and charging currents of the two terminals alone, neglecting the circuit and corona losses and using the most favorable arrangement of the two terminals. While this consideration may not be proportionately unfavorable for one million volts, the charging currents of any transformers or condensers in the circuit are certain to be enormously greater than the leakage of the terminals alone, no matter what equipment is used. The Van de Graaff generator requires only enough input to operate its driving motor, which for a one-million-volt generator is less than 0.2 kilowatt.

Alternating current equipment for the production of high voltage consisting of transformers, condensers, and rectifying tubes is very expensive because of the high insulation requirements. On the other hand, the extremely low cost of the Van de Graaff generator, especially when compared to other sources of voltages of similar intensity, serves to make the use of the machine greatly desirable wherever it may be applied.

APPLICATION

Two Van de Graaff generators have been constructed in the department of electrical engineering at the University of Kansas in order to provide for the laboratories a source of high voltage with the characteristics of this type of generator. The first machine was designed by Mr. P. F. Meigs for a maximum potential between 50,000 and 100,000 volts and gave reasonably successful results. This first generator was dismantled after the construction of the second machine, since it was primarily of value as an experience guide in the

construction of the latter. The present generator was designed to attain a potential in the neighborhood of 1,000,000 volts with a view to enlarging, for both the electrical engineering and physics departments, the available field of research which requires high-voltage technique.

DESCRIPTION

As is seen in Figure 1, the base of the generator is a box-like structure which incloses a motor, a heater, and an external exciting circuit consisting of a 15,000-volt kenetron set. On one end of the box, mounted vertically, is a 68-inch textolite tube, 10 inches in diameter, with its end opening into the base directly over the motor pulley. The upper pulley head is mounted in the upper end of the textolite tube, slipping into it and supported by a ring of textolite cemented inside the tube. A belt passes over the two pulleys and through the hollow tube. A metal sphere, one meter in diameter, is mounted on and around the upper pulley head, fitting snugly over the base of the head and resting on the upper edge of the textolite tube.

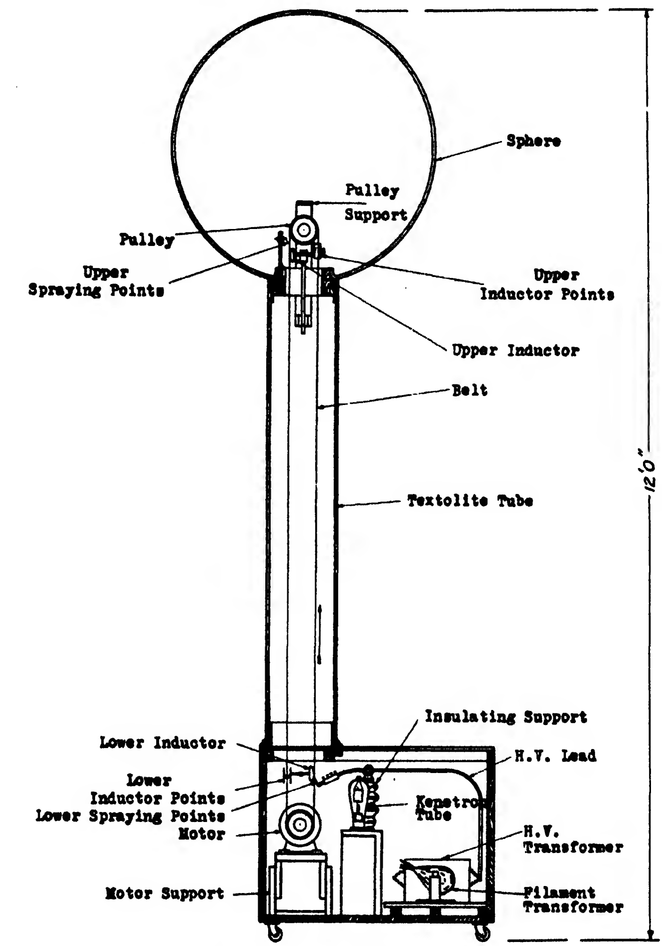
PRINCIPLES OF OPERATION

The theory of operation of the Van de Graaff generator is that of the deposition of charge on a sphere by means of a rapidly moving flexible belt made of an insulating material. The charge may be transferred to the belt without any externally applied voltage, or it may be sprayed on by the maintenance of a voltage drop to the belt. These conditions of operation may be termed "self-excited" and "externally excited," respectively.

Referring to Figure 1, the charge is sprayed onto the belt by the lower spraying points, connected to the ground for self-excitation or to the high side of a rectifying circuit when alternating current is used for external excitation. The charge is drawn off the spray points by the lower "inductor," which is maintained at an opposite charge by the belt friction. If the lower inductor is maintained at a negative charge, a positive charge is drawn from the lower spraying points toward the lower inductor but is deposited on the rapidly moving belt and carried up inside the sphere.

After entering the sphere, the charge is drawn off the belt by the multiple sharp points of the upper inductor, thus causing that inductor to be charged positively. The maintenance of a positive charge on this inductor causes negative charges to be drawn from the sphere toward the inductor by means of the upper spraying points, but these charges, like those ascending, are deposited on the belt and are carried down to be caught on the points on the left-hand side of the lower inductor, thus making the negative charge thereon even greater. The departure of the negative charges from the sphere makes it bear a positive charge with respect to the earth. In a general way, and disregarding the charges of the various parts except those on the belt, it can be seen that, under the conditions assumed, positive charges are moving upward and negative charges are moving downward. Hence a net positive charge is being accumulated on the sphere.

The term "inductor" is used by the authors merely because it is expressive of the function of that piece of the apparatus in holding a charge and "inducing" the spraying points to pass the charge to the belt. It should not be confused with the same term applied to devices employing electromagnetic



THE VAN DE GRAAFF HIGH-VOLTAGE GENERATOR

Electrical Engineering Laboratory
University of Kansas 1934 FIG. 1. Scale = 1'

induction. There is no electromagnetic action in the self-exciting Van de Graaff generator.

Returning to the discussion of the charges on the inductors and the sphere, it can be seen that all these charges are cumulative, and since the earth is an unlimited source of charge, the ultimate potentials of these three parts are governed by the charge that can remain on them. The paths for leakage of current from these parts are of course the surrounding medium of air and the supports of the three parts.

The maintaining of a high potential on the inductors is not possible nor necessary, but the sphere is designed to permit as high a charge, and hence voltage, as possible to be built up on it. The useful potential of the machine is the potential between the sphere and the earth, or between the sphere and an oppositely charged sphere of another machine.

The polarity of the charge on the sphere depends only upon the polarity with which the machine starts to build up. For instance, if the lower inductor at the start happens to have a positive charge, a negative charge is drawn from the earth and up the belt, the upper inductor and the sphere are both charged negatively, and positive charges descend on the left. In this case the sphere would acquire a negative potential with respect to the earth, whereas its resultant potential would be positive if the original charge on the lower inductor had chanced to be negative.

However, since the sparking potential of a point negatively charged is higher than that of one with a positive charge, it follows that, for a given voltage, a greater current will pass from a point positively charged than from one negatively charged. In other words, for a given potential, a positive charge has a greater tendency to pass from a point than does a negative charge. Hence, when the machine is self-excited, positive starting is more likely to occur.

VOLTAGE OBTAINED

Since no satisfactory means of measuring potentials of this magnitude were immediately available, the voltage at sparkover was calculated from the measured sparkover distance. The longest sparkover distances observed and measured were as follows:

68.5 centimeters to grounded 61-centimeter sphere
145 centimeters to grounded 12.7-centimeter sphere
173 centimeters (68 inches) to grounded sharp objects.

The last item was the discharge down the tube and directly through the air to the angle-irons in the base. The length of the tube, 68 inches, was naturally the limit of the length of the discharge to almost any object since the edges of these angles were sharp and the angles were grounded. The sparkover voltages were computed from experimental and calculated values appearing in "Dielectric Phenomena in High Voltage Engineering," by F. W. Peek, Jr. Using Peek's values and methods, it was found that this electrostatic generator can produce a potential of more than 600 kilovolts when sparking over a distance of 68.5 centimeters to a 61-centimeter (2-foot) sphere. The radii of the sharp objects could not be obtained accurately and the 145-centimeter sphere had a circular collar where the ring was attached for hanging. Hence any voltage value calculated from these sparkover distances could

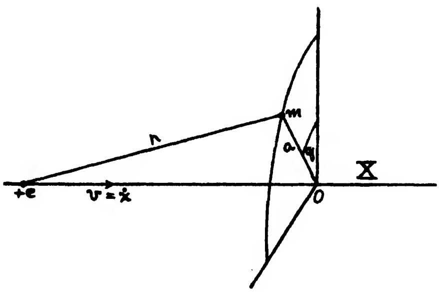
not be considered accurate. In a few cases a discharge was obtained to the 61-centimeter sphere over a distance of about 90 centimeters, which indicates that the generator under favorable conditions produces a potential of 800 kilovolts. With improvements in the design and adjustment of the parts of the generator, this higher voltage should be obtained regularly and a potential of 1,000,000 volts is not out of reason.

The Whittaker Quantum Mechanism

F. E. KESTER, University of Kansas, Lawrence, Kan.

In an attempt to strengthen an analogy, recurring with some regularity in one of my mechanics courses, between the series of multiple values assumed by the potential energy function $-\int_1^2 Q\, dq = V_2 - V_1$ when applied to the case of a magnet pole carried cyclically in a path linking with a current bearing electric circuit, and, on the other hand, the similar series of discreet values assumed by the Maupertius action integral $\int p\, dq$ when evaluated for a repeated periodic process, I was led to a discussion of the latter integral for the special case of an isolated magnet pole, the Dirac[1] "magnetic quantum" m, carried in a closed path linking with a closed path of an elementary charge of electricity e. The analogy is the more interesting in that the two functions here involved are useful in expressing, by minimum values of each, the conditions for equilibrium of mechanical systems in conservative fields of force—the potential energy function at minimum value for static equilibrium, the Maupertuis function, evaluated for the natural "path" of a system between any two configurations, at minimum value for "kinetic equilibrium" with the field for this path.

Whittaker[2] discussed the interchanges of energy occurring in the special case of an electron flying along the axis of a magnetic wheel the spokes of which are magnets with their south poles (say) at the center, the north poles at the rim. The expedient of placing one set of poles at the axis to avoid the magnetic action of the flying electron upon them is, of course, not feasible. Lorentz[3] corrected this feature of the Whittaker mechanism by assuming an isolated pole, giving it the form of a plane circular filament, closed on itself and free to move only in rotation about its own axis, and he generalized the problem to cover any form of the electron's path which may link with the filament.



To bring out a peculiar relation found during discussion of the problem, it will suit best to consider the mechanism in a form slightly modified from that used by Whittaker. A charge $+e$ (in e.s.u.) flies in a straight line, say the x-axis, and as a result of its motion affects an isolated north pole m (in e.m.u.) which is constrained to move in a circular path of radius a, with the line of flight of e as its axis. Let c = the velocity of light, Q the moment of force

1. P. A. M. Dirac, Proc. Roy. Soc. London, *133*, 60, 1931.
2. E. T. Whittaker, Proc. Roy. Soc. Edinburgh, *42*, 129, 1922.
3. H. A. Lorentz, Proc. Konink. Akad. Amsterdam, *25*, 414, 1922.

about the x-axis exerted upon m by the magnetic field of the electron flying with the velocity dx/dt, and p the angular momentum of m. Then

$$Q = dp/dt = (e/c\ r^2)(dx/dt)m\ a\ sin\ (x,r) = (e\ m/c)\ a^2\ (dx/dt)/(a^2 + x^2)^{3/2}$$

Integrated, this equation gives

$$p = (e\ m/c)\ x/(a^2 + x^2)^{1/2} + \text{constant}.$$

If we assume $p = O$ when x is — infinity, the constant becomes $e\ m/c$, and

$$p = (e\ m/c)\left[x/(a^2 + x^2)^{1/2} + 1\right]$$

Obviously the same expression would result for the angular momentum of e if the paths of e and m were interchanged.

The value of p, as given by the expression above, depends upon only the position of e in its path; it is independent of the velocity of e. This was shown by Whittaker in his expression for the resulting energy. If e had initially sufficient energy to enable it to reach + infinity, the moment of momentum finally acquired by m is $2\ e\ m/c$.[4]

If we postulate the laws of quantum mechanics for the periodic circular motion thus imparted to m, the integral $\oint p\ dq = h$ becomes here

$$\oint p\ dq = p \oint dq = 4\pi e\ m/c = h.$$

If, further, we assign to e and m the respective quantum values, we have the Dirac relation between these quantities.

4. The same expression for p results from the Whittaker-Lorentz expression for the energy acquired by the pole system due to a completed flight of the electron, namely, $E = p^2/2I = 2\ e^2m^2/c^2I$, where I is the moment of inertia of the pole system.

Mass Defects and Nuclear Structure

PAUL M. STRICKLER, University of Kansas, Lawrence, Kan.

Light nuclei may be roughly described in terms of protons and neutrons held together by so far unknown binding forces. The binding energy Σ is obtained at expense of mass, the mass defect Δm being $\Delta m = \Sigma/c$. For a mass to be stable the mass defect increases as particles are added. We would expect a periodicity, similar to the periodicity in ionization potentials of elements of the periodic system, for the binding energies of nuclei. Starting from a pure proton and neutron picture as described by Bartlett,* we would expect that two protons and two neutrons could exist in the ls level and six more of each could exist in the lp level. Thus we would expect the first break at He 4 and the second at 0 16. Mr. L. H. Horsley, at Kansas University, has shown that the regularities in the anomolous scattering of alpha-particles in-

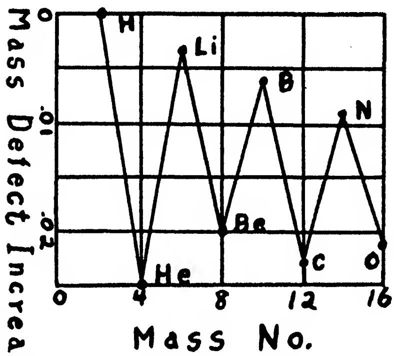


Fig. 1

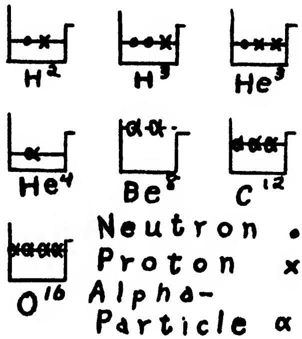


Fig. 2

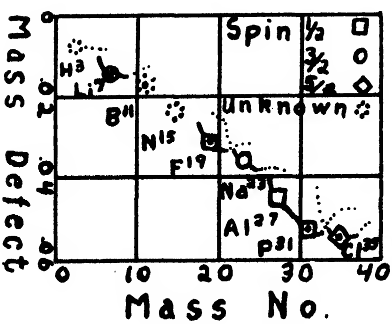


Fig 3

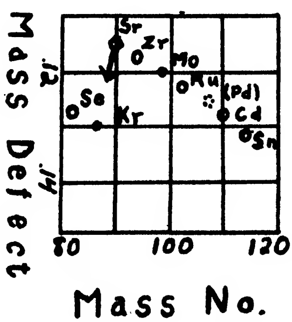


Fig. 4

* J. H. Bartlett, Physical Review 41:370.

dicate that several alpha-particles may exist in the nucleus, and that our simple picture suggested above may be inadequate above Li 7. Using Deutons as the particle to be added to the nuclei, and plotting mass defect increases, we get the results shown in fig. 1. The distinct periodicity of four is noticed at once. A diagram of possible arrangements of nuclear particles in the light of Mr. Horsley's results is shown in fig. 2.

The question arises as to whether Mr. Horsley's model provides us with a sufficient basis to attack the problem of nuclear spins. It fits nicely into Mr. Horsley's picture that the atoms of mass 4n have zero spins, corresponding to alpha-particles in the ls state. But no definite conclusion can be drawn in the case of nuclei containing protons and neutrons in addition to alpha-particles. We must first investigate so far unknown orbit and spin couplings, which may give rise to a splitting of the energy levels. If we regard the atoms of mass $4n + 3$ we get the results shown in figure 3, indicating several close energy levels of spin $\frac{1}{2}$, $\frac{3}{2}$, $\frac{5}{2}$. Further knowledge depends partly on further data.

It was decided to investigate the mass defects of nuclei for which data were available, with the hope of gaining further insight into nuclear structure. In view of the stability of alpha-particles, their existence as intra-nuclear particles at least in light nuclei, and their emission by radio-active substances, it was decided to group atoms so that those which differed by alpha-particles fell in the same group. Accordingly, all atoms differing by 4n mass units were placed in one group. Atoms differing by alpha-particles, that is by two units of charge and four units of mass, were arranged in a series. Such series were found to contain from two to ten elements. Then for some reason they ended, perhaps because of alpha or beta activity.

Within a series, the mass defects must increase as we go to heavier atoms. A decrease of mass defect as particles are added means instability and the atom with the smaller defect may disintegrate into the next lighter atom of the series, by emission of an alpha particle with an energy equal to the energy difference of the two atoms. It was noticed that Mo 98 has a smaller mass defect than Kr 86. Sr 90 was missing from the list of isotopes, indicating that the smaller mass defect of Mo 98 could be explained by alpha activity of Sr 90, making the series containing them Se 82, Kr 86, (Sr 90 alpha active), Sr 94, Mo 98, Rn 102, (Pd 106 uncertain), Cd 110, Sn 114. A similar series was found to be Os 192, (Pt 196 alpha active), Hg 200, Pb 204, the Hg 200 having a smaller mass defect than Os 192, and Pt 196, being missing from the list of isotopes. Unfortunately only two mass defects were available for each of the two series mentioned, but either Sr 90 and Pt 196 are alpha active, or the masses given are in error. A mass defect curve for the first series is given in fig. 4.

Data were taken from "Kernbau und Quantenmechanik," Handbuch der Radiologie, Vol. VI/I, 2d ed, 1933, by Dr. Guido Beck.

I wish to thank Doctor Beck for his many suggestions and help.

Earth Resistivity as Affected by the Presence of Underground Water

ROBERT W. WARNER, University of Kansas, Lawrence, Kan.

Resistance to the passage of a current of electricity is a property of all inert materials, including metals, ores, rocks, soil and the so-called nonconductors or insulators. When a convenient unit volume is considered, usually the cubic centimeter, this property is known as specific resistance or resistivity. The unit of resistivity is the ohm, which is the resistance offered by a column of mercury 106.3 cm. long, weighing 14.4521 gm. at 0°C.

Reciprocal terms corresponding to resistivity and resistance are conductivity and conductance. It is considered at the present time that degree of conductivity is dependent upon the number of free elections drifting about within a material when it is under normal temperature conditions and unaffected by external electrical fields or potentials. Good conductors possess a large number of free electrons, while poor conductors have few, and those materials of such low conductivity as to be classed as insulators have almost no unattached electrons under normal conditions.

Much difficulty arises in determining the resistivity of different kinds of rock and soils and there has been considerable variation in the results of tests made at different times and places, probably largely due to variations in moisture content as well as to less important differences in the exact chemical composition of the samples taken.

In their work entitled "Applied Geophysics," A. S. Eve and D. A. Keys give some interesting values of resistivity for certain types of rocks, soils and minerals as follows:

	Ohms per cubic cm.
Granite	10^9 to 10^{11}
Limestone	6.8×10^4
Sandstone	5.0 to 100×10^9
Coal	10^9 to 10^{17}

By way of comparison with common insulating materials:

Glass	10^7 to 10^{12}
Sulfur	10^{11} to 10^{14}
Mica	9×10^{15}
Rubber	10^8 to 10^9
Slate	10^2 to 10^4

Moisture present to any extent whatever greatly lowers the resistivity of rocks and soils. If rocks are sufficiently porous to contain appreciable water with salts in solution the resistivity may drop to that of the salt solution.

Dry sand has a resistivity practically the same as that given above for sandstone. Perfectly dry soil has a similar value. With only a small amount of water present Eve and Keys found results as follows:

	Ohms per cubic cm.
River sand containing 0.86% water	830
River sand containing 1.5% water	380
River sand containing 9.5% water	95
Garden soil containing 3.3% water	1,670
Garden soil containing 17.3% water	60

		Ohms per cubic cm.
Common clay containing 4.4% water	....	1,450
Common clay containing 16.1% water	....	50
Common clay containing 28.0% water	....	16

Continuing for comparison into the class of materials known as conductors, copper has a resistivity of 1.73×10^{-6} ohms per cubic centimeter which corresponds to 10.8 ohms per mil foot. Aluminum has a value of 2.83×10^{-6} ohms per cubic centimeter. Conducting ores exhibit intermediate values of resistivity ranging from 0.01 to 1.0 ohms per cubic centimeter.

Earth resistivity may be considered in two ways. The first is as discussed above where a sample is taken out and the resistance measured under laboratory conditions. In the second the characteristics of soils, gravel and rocks are considered in place and undisturbed in the earth where the moisture content may be anything from zero up to almost 100 percent. The bare resistivity of various samples of gravel or soil means little; however, the resistivity of the same in place in the earth may form a valuable indication of the moisture or water content beneath the surface.

If the earth were perfectly homogeneous the problem of determining the resistivity would be quite simple. This is usually not the case, although for a stratum of considerable thickness the material may be approximately uniform but differing in moisture content between upper and lower sections. Any method of measuring the resistivity of the soil in place must therefore involve a depth factor as well as furnish an indication of the average resistivity.

RESISTIVITY MEASUREMENT

Measurements of the resistivity of the earth are subject to certain errors for which corrections must be made unless they can be eliminated in some manner by the measuring apparatus. The most important of these disturbing factors are stray earth currents and polarization at the point of contact between electrode and soil. If direct current is employed for the measurement, a porous-pot device must be used to eliminate the polarization at the electrodes and corrections must be made for any stray earth currents. This latter is extremely difficult because the potentials due to such currents may even be equal to or greater than those it is desired to measure. Also they fluctuate quite rapidly and frequently reverse in direction.

A method which eliminates both of these sources of error has been suggested by O. H. Gish and W. J. Rooney of the Carnegie Institute of Washington. Four electrodes are spaced at equal intervals in a straight line and driven into the earth far enough to insure good electrical contact. A current of approximately 200 milliamperes is introduced at the outer electrodes and the potential drop between the middle electrodes is determined by means of a potentiometer.

A hand-driven, two-segment commutator is used to alternate the earth current at a frequency of approximately fifteen cycles per second. Since a potentiometer will measure only direct voltages it is necessary to rectify the potential drop between the two inner or pick-up electrodes in exact synchronism with the alternations of the measuring current. This is readily accomplished by means of a second identical commutator on the same shaft with the reversing device.

These current reversals are rapid enough to prevent polarization at the

pick-up electrodes and also are sufficient to cancel the effect of any natural, stray earth currents. At the same time the frequency is not high enough to introduce inductance effects except where attempts are made to include depths of 100 feet or more within the range of the measurements.

In this method of determining earth resistivity the contact resistance of the outer electrodes has no effect on the results as long as the source of current supply has sufficient voltage to send a current of usable magnitude into the earth. Ordinary radio "B" batteries with voltage ranges from 22½ to 90 volts are usually satisfactory for furnishing this current. The contact resistance of the pick-up electrodes also has no effect because no current is drawn from these points. The voltage of the potentiometer merely balances the voltage drop between the electrodes without taking any current from them.

With a four-terminal conductor arrangement of this type Frank Wenner, of the United States Bureau of Standards,* has shown that the average resistivity of the earth section lying between the pick-up electrodes is given by the equation—

$$\rho = \frac{4\pi D \left(\dfrac{E}{I}\right)}{1 + \dfrac{2D}{(D^2 + 4A^2)^{1/2}} \quad \dfrac{D}{(D^2 + A^2)^{1/2}}}$$

where D is the separation of the electrodes, E is the potential drop between the pick-up electrodes as determined by the potentiometer, I is the current sent into the earth, and A is the depth of the electrodes in the ground. When D is measured in centimeters the calculated resistivity is in ohms per cubic centimeter. If D is in feet the resistivity is in ohms per cubic foot.

When measurements are made from the surface of the earth the depth A is relatively very small compared with D and may be omitted from the calculations. The resistivity equation then becomes—

$$\rho = 2\pi D \left(\frac{E}{I}\right)$$

Current in passing through the earth from one terminal electrode to the other will seek the path of lowest over-all resistance. If the soil is entirely homogeneous and of equal resistivity throughout the current would approach a uniform distribution in the volume lying between the pick-up points. This volume approximates a semicylindrical form with height equal to the electrode separation. If the radius be taken as equal to 2D, twice the electrode separation, the resistivity of the cylinder would be given by the equation—

$$\rho = \frac{E}{I} \frac{\text{Area}}{\text{Length}} \quad \text{or} \quad \rho = 2\pi D \left(\frac{E}{I}\right)$$

which is the same result obtained in a different manner by Wenner. This would indicate that for a homogeneous soil the current penetrates to a depth approximately equal to twice the separation of the pick-up electrodes. The

* U. S. B. S. Bulletin (1916) 12, No. 4.

resulting value of resistivity applies to the entire volume of earth from the surface down to this depth.

In most actual cases the soil is decidedly nonhomogeneous. Therefore the value of resistivity thus calculated from test data can be treated only as an apparent average resistivity.

The presence of strata of different individual resistivities will greatly alter the current distribution in the soil. A high resistance stratum will force more current to flow near the surface, the potential between the pick-up electrodes will be high and the calculated resistivity high. On the other hand, a stratum of relatively low resistivity, lying at some distance below the surface, will form a path of greater conductivity with the result that less current will flow near the surface, the potential between the pick-up electrodes will be lower and the calculated value of resistivity correspondingly lower.

Field data indicate that the effect of a layer having a resistivity either higher or lower than that of the soil above appears in the results when the electrode separation is very closely equal to the depth of the layer. A series of measurements may be made starting with a small electrode separation and continuing with uniformly increasing separation until a reasonable limit is reached. Inspection of the curve of resistivity plotted against electrode separation will show the presence and approximate depth of any strata differing appreciably from the soil above it. In this manner the depth of bedrock may be determined as well as the presence and extent of water-bearing gravel or sand.

FIELD APPARATUS

A relatively small amount of apparatus is required for making such resistivity measurements in the field. A standard potentiometer of the portable, or "students' type," potentiometer battery of approximately 3 volts, standard cell and galvanometer comprise the equipment necessary for measuring the potential between the pick-up electrodes. A double-commutator mounted on a gear-driven shaft reverses the current flowing through the earth and also rectifies the potential from the pick-up electrodes. A block of dry cells with a voltage range up to 90 or 100 volts will supply the earth current while a milliammeter of two or more ranges will serve to measure this current. Additional miscellaneous equipment consists of copper-clad steel pins two feet long and five eighths of an inch in diameter, flexible wire, wooden stakes and tape line.

The potentiometer is preferred over other potential measuring devices because it draws no current from the pick-up points and will give results accurate to three significant figures. This is quite necessary if a critical analysis of the results is expected.

The schematic arrangement and connections of the apparatus are shown in Figure 1. The circuit connections of both potentiometer and commutators are clearly indicated. An approximate idea of the relation between current flow, depth of current penetration and pick-up electrodes is shown.

RESULTS OF RESISTIVITY TESTS

A large amount of field work has been done in an effort to establish more definitely the relation between resistivity and ground water. In some cases tests were made at locations where the logs of bored holes were already avail-

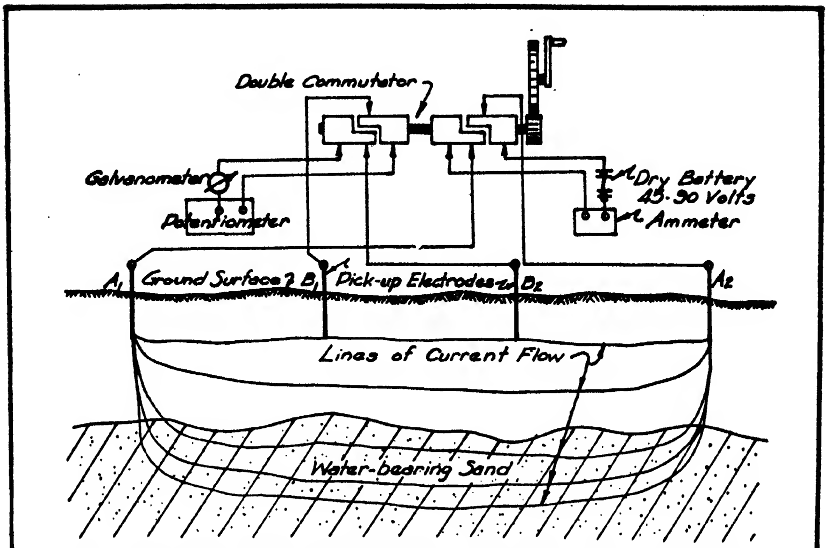


Fig 1 - Wiring Diagram Showing Paths of Currents Thru The Earth

able. These data served as a definite check on the electrical results. At other places test holes were drilled in order to verify the electrical findings.

Typical curves selected from a large number of tests at widely separated locations and under a variety of different conditions are shown in Figure 2.

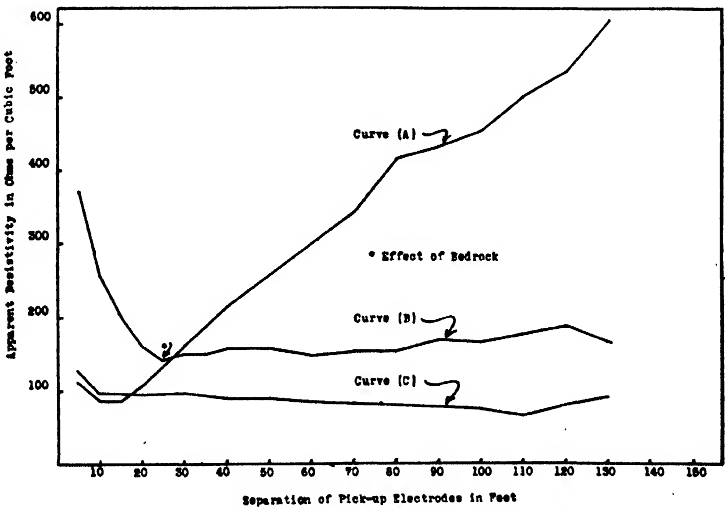


FIG. 2. Typical resistivity curves showing the effect of dry bedrock and water-bearing gravel.

Curve (A) was obtained on a high tertiary deposit. At the surface the resistivity was comparatively low, evidently because of a slight amount of surface moisture. As the electrode separation was increased and greater depths became included within the range of the measurements the resistivity increased quite rapidly, indicating that the tertiary sand contained very little moisture. To the approximate depth of 110 feet the apparent average resistivity shown is 500 ohms per cubic foot, or 15,250 ohms per cubic centimeter. When this is compared with the 830 ohms per cubic centimeter reported by Eve and Keys for sand containing 0.86 percent water it is evident that at the location above the moisture content was negligible.

An entirely different condition is indicated by the results shown by curve (B). The initial surface resistivity was quite high due to a sun-baked top soil. Moisture below the surface caused a steadily decreasing resistivity until bedrock was reached. The curve shows the effect of this at the 30-foot point. In a bored test hole at this location bedrock was struck at thirty-one feet. There was sufficient moisture just above bedrock to prevent any appreciable amount of current from getting below it. This accounts for the almost constant resistivity beyond the twenty-five-foot electrode-separation point. The slightly rising trend of the latter part of the curve suggests that if the electrode-separation had been increased beyond 130 feet the curve would turn upward, indicating the presence of little moisture within the bedrock itself.

Curve (C) shows results from tests made in the flood plain of a small creek. It shows the presence of considerable moisture below the surface, as might be expected in such a location. The soil was somewhat sandy. Water was struck at 35 feet, which accounts for the dip in the curve at the 40-foot point. The general trend of the curve is downward to the 110-foot point, although bedrock was reached at 55 feet. There were eight feet of water-bearing gravel just above the rock. Apparently this was such a good conductor that most of the current followed it until the 110-foot separation point was reached. Here the current began to penetrate the bedrock, and the upward turn in the curve indicates the presence of little moisture in the rock itself.

The results of two series of tests made in a wide river bottom are shown in Figure 3. The locations were 600 feet apart and the general trend of both curves is quite similar. The effect of the water table is clearly indicated by a distinct reduction in resistivity and a change from a rising to a downward characteristic at the points marked on the curves. The effect of bedrock appears as a temporary increase in resistivity. The fact that both curves turn downward again would seem to indicate the presence of considerable moisture within or below the bedrock itself.

Test holes at both of these locations yielded water at the rate of approximately one thousand gallons per hour when tested experimentally with hand pumps.

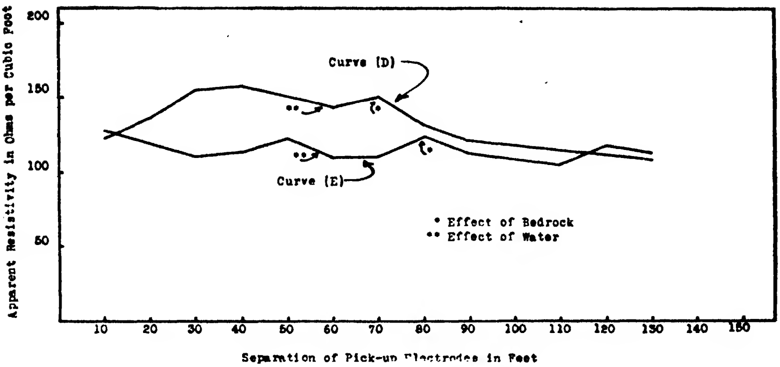


FIG. 3. Resistivity curves in river flood plain showing the effect of ground water and bedrock.

CONCLUSION

From the results of tests already made it is quite evident that there is a very close connection between the apparent average resistivity as determined by the method described above and the presence of moisture or water below the surface of the earth.

The trend of the resistivity curve is more significant than the absolute value of resistivity at any particular point. This is because of a wide variation in the nature of the soil as well as in the character of the underlying bedrock in different localities. In general a rising characteristic is evidence of diminishing moisture as the depth increases, while a drooping curve is a sign of the presence of ground water.

An impervious bedrock will prevent water from penetrating lower and a sharp break in the resistivity curve will appear near the electrode separation equal to the depth. On the other hand, a porous bedrock may contain so much water that the resistivity is practically the same as that of the water-bearing gravel above. In this case there will be nothing on the resistivity curve to denote the line of demarkation between soil or gravel and bedrock.

For these reasons a knowledge of the geology of the region is extremely important as an aid in correctly interpreting the results of the resistivity tests. In general the conclusions are largely qualitative in nature although it is possible that further study of the results from more extended field tests coupled with a thorough knoweldge of the geology involved will permit of a certain degree of quantitative interpretation.

A Simple Method of Color Matching

RICHARD H. ZINSZER, Indiana University, Bloomington, Ind.

Considering spectrum colors as having 100 percent purity, it is possible to use them in conjunction with white light for the purpose of matching the color of given samples. Thus colorimeters of the monochromatic type have been described by Nutting[1] and by Priest.[2] The present method is a modification of the work of the investigators.

THEORY

To understand why it is possible to match colors by a mixture of white light with a monochromatic light produced by a dispersing system, it is necessary to understand the color triangle and distribution curves of samples.[3]

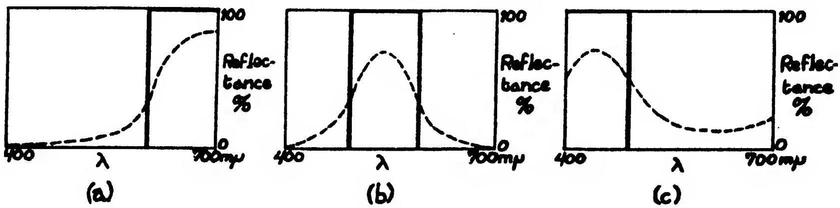


FIG. 1. Distribution curves.

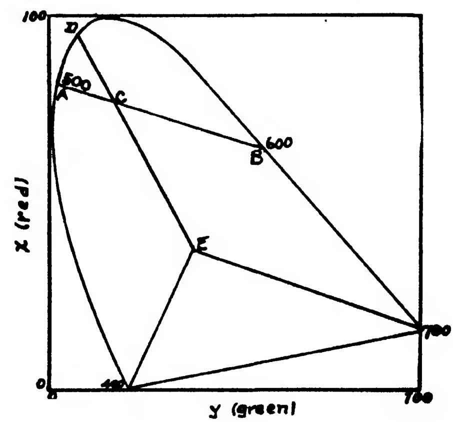


FIG. 2. Color triangle. Trilinear coördinates of the spectrum referred to stimulus primaries.

In Figure 1 the reflectance value of 100 percent corresponds to the action of pure white light on magnesium oxide used as the reflecting medium. The full line of (*a*) in this figure represents the reflectance and the distribution of

1. Sci. Paper 187, Bur. Standards Bull., 9, 1 (1913).
2. Jour. Opt. Soc. Amer. and Rev. Sci. Instr., 8, 173 (1924).
3. Hardy and Perrin: *The Principles of Optics*, pp. 304-310 (McGraw-Hill, 1932).

a perfect red, while the dotted curve on the same graph represents that of the red we generally see, other than spectrum red. In (*b*), the solid line shows the reflectance of a perfect green, which, like the red, reads either zero or 100 percent, while the dotted curve represents the general type of green. In (*c*), the solid line shows the reflectance and distribution of an ideal blue while the dotted curve indcates that of an ordinary blue.

These curves represent the reflectance of particular samples as a function of the wave-length, using magnesium oxide as a standard.

The color triangle in figure 2 is drawn using the trichromatic theory to designate a point. Thus:

$$x + y + z = 1$$

where x, y and z are the trichromatic coefficients, and are equal by definition, respectively, to—

$$x = \frac{X}{X+Y+Z} \qquad y = \frac{Y}{X+Y+Z} \qquad z = \frac{Z}{X+Y+Z}$$

X, Y, and Z represent the excitation values under the distribution curves in figure 1. These values are obtained in the following manner:

$$X = \sum_{0}^{\infty} \bar{x}_\lambda E_\lambda R_\lambda \qquad Y = \sum_{0}^{\infty} \bar{y}_\lambda E_\lambda R_\lambda \qquad Z = \sum_{0}^{\infty} \bar{z}_\lambda E_\lambda R_\lambda$$

where $\bar{x}_\lambda$, $\bar{y}_\lambda$, and $\bar{z}_\lambda$ are called the distribution coefficients by Judd[4] of the Bureau of Standards. E_λ is the energy of the source as a function of the wave length, while R_λ is the ordinate of the curves or percentage reflectance as a function of the wave length.

With the aid of this information the values of the trichromatic coefficients can be quickly plotted on the color triangle. By passing a line from the white point, E, through (x, y, z) to the intersection with the border, one obtains the dominant wave length, while the purity depends on the distance from the spectrum locus to the point in question. The triangle can be reproduced in section and these individually enlarged to the size of graph paper.

Thus in Figure 2, C is any ordinary color which can be reproduced by adding the amount AC of the spectrum color B to the amount CB of the spectrum color A, or by adding the amount DC of white light to the spectrum color D. The latter procedure is followed in matching the samples given in this experiment.

APPARATUS AND PROCEDURE

As indicated in Figure 3, the apparatus consists of sample blocks with one side colored and one side white, a carbon arc for producing monochromatic light, an optical bench, a glass prism, an ordinary white light with electrical connection, and a lens.

In carrying out the experiment, there are two degrees of freedom through which the sample block may be moved. The first is the choice of spectrum color to which the sample corresponds. The second is a change in intensity of the white light projected on the block, the latter being accomplished by moving the block along the optical bench until a match is obtained.

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4. Rp. No. 163, Bur. of Standards Jour. of Research, 4, 515 (1930); Jour. Opt. Soc. Amer., 23, 359 (1935).

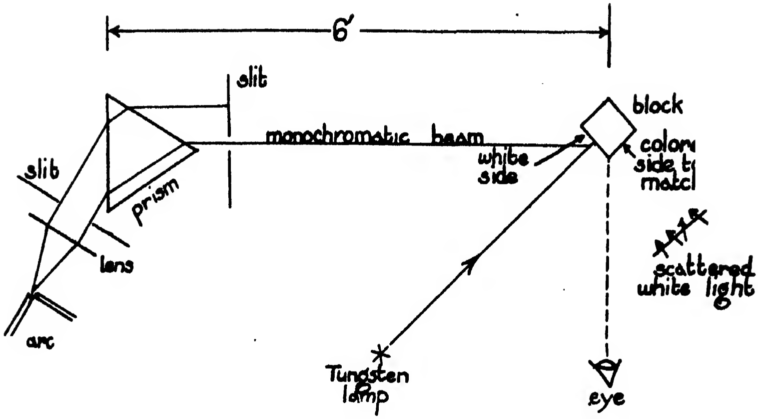

FIG. 3. Arrangement of apparatus for matching colors.

This experiment is entirely qualitative and was initially set up to verify a bit of theory connected with the color triangle, and not to determine dominant wave length and purity.

However, it is possible to measure the dominant wave length with the aid of a monochromator. Then, if the white face of the sample block is the purest white magnesium oxide surface, the ratio of the energy from the white light may be compared to that of the spectrum wave length and the purity may thus be determined. To measure the energy of the white source (a source of temperature 6500°K is assumed), and that of the spectrum line, a non-selective measuring device should be used, if there are any. These determinations, however, are made more easily by means of the spectrophotometer such as the one described by the writer elsewhere in this volume.

Relation Between Reading Test Scores and Freshman Grades

NICHOLAS D. RIZZO, University of Kansas, Lawrence, Kan.

The data reported are taken from tests administered to 591 freshmen entering the University of Kansas in September, 1933. The two tests are Thurstone Psychological Examination, 1933 edition, and Minnesota Reading Examination, Form A, by Haggerty and Eurich. Freshman grades refer to the first two semesters' marks made by the entering students. These data were secured from the registrar's permanent records.

This paper is a synopsis of the writer's master's thesis, of which the faculty advisor is Dr. A. H. Turney, School of Education, University of Kansas. The first section deals with a treatment of the data, not taking into account differential prediction, which is the subject of the second part.

Below is a key to the abbreviations of the variables used in the statistical treatment in both sections.

1. G. P. A.—Grade-point average. Both semesters of the school year, 1933-1934.
2. A. C. E.—Raw scores on the Thurstane Psychological Examination.
3. Read. Voc.—Reading Vocabulary score on the Minnesota Reading Examination.
4. Read. Comp.—Reading Comprehension score on the Minnesota Reading Examination.
5. Read. Total.—Score on 3 plus score on 4 the Minnesota Reading Examination.

PART I

The data were grouped according to the school in which the students were enrolled. Coefficients reported were obtained by the Pearson r- technique, using the Otis Correlation Charts.

School of Pharmacy—14 Students

	2	3	4	5
1. G. P. A.	.41 ± .15 K = .91	.18 ± .17 K = .98	.36 ± .15 K = .93	.23 ± .17 K = .97
2. A. C. E.	....	.73 ± .09	.71 ± .09	.85 ± .05
3. Read. Voc.	....	....	X	X
4. Read. Comp.	....	....	....	X
5. Read. Total	....	....	....	....

School of Fine Arts—40 Students

	2	3	4	5
1. G. P. A.	.31 ± .09 K = .95	.30 ± .09 K = .95	.32 ± .09 K = .95	.44 ± .09 K = .90
2. A. C. E.	....	.81 ± .03	.41 ± .08	.66 ± .06
3. Read. Voc.	....	....	X	X
4. Read. Comp.	....	....	....	X
5. Read. Total	....	....	....	....

School of Engineering—89 Students

	2	3	4	5
1. G. P. A.	.67 ± .04 K = .74	.50 ± .05 K = .87	.43 ± .06 K = .90	.47 ± .05 K = .88
2 A. C. E.	....	.70 ± .03	.58 ± .03	.69 ± .04
3. Read. Voc.	....	....	X	X
4. Read. Comp.	....	....	....	X
5. Read. Total	....	....	....	....

COLLEGE OF LIBERAL ARTS AND SCIENCES—448 STUDENTS

	2	3	4	5
1. G. P. A.	.62 ± .04 K = .78	.54 ± .05 K = .84	.67 ± .03 K = .74	.68 ± .03 K = .73
2. A. C. E.	....	.68 ± .03	.69 ± .03	.75 ± .03
3. Read. Voc.	....	....	X	X
4. Read. Comp.	....	....	....	X
5. Read. Total	....	....	....	....

TOTAL FRESHMAN GROUP—591

A. *Zero-order Correlations:*

	2	3	4	5
1. G. P. A.	.55 ± .03 K = .84	.44 ± .03 K = .90	.47 ± .03 K = .88	.58 ± .03 K = .81
2. A. C. E.	....	.70 ± .02	.61 ± .03	.72 ± .02
3. Read. Voc.	....	....	X	X
4. Read. Comp.	....	....	....	X
5. Read. Total	....	....	....	....

3. *Partial correlations:*

r12.5 = .23 r15.2 = .31 r12.3 = .38 r12.4 = .37

C. *Multiple correlations:*

R1(25) = .61 R1(23) = .56 R1(24) = .58
K = .79 K = .83 K = .81

From the data already presented two conclusions can be drawn. (1) To a very significant degree the Reading Examination and the Psychological Examination measure the same thing. The relatively small partial coefficients bear out this fact. (2) The Minnesota Reading Examination is the best single basis for predicting G. P. A. The multiple coefficients are only a slight improvement over the Zero-order correlations.

The predictive value of a coefficient of correlation is obtained by the K- technique described in Garrett's—Statistics in Psychology and Education. The coefficient of alienation (K) gives the percentage of error which the correlation coefficient has.

PART II

This section deals with predicting grades in the various subject fields. In each table of correlations G. P. A. will denote the grade point average in the subject field concerned. The total freshman population is represented, by samplings, in each case, excepting in the last two tables where we deal with the total Fine Arts group.

ENGLISH SUBJECTS

A. *Zero-order correlations:*

	2	3	4	5
1. G. P. A. (English Subjects)	.52 ± .04 K = .85	.53 ± .04 K = .85	.55 ± .04 K = .84	.61 ± .03 K = .79

B. *Partial correlations:*

r12.5 = .01 r15.2 = .41 r12.3 = .24 r12.4 = .27

C. *Multiple correlations:*

R1(25) = .62 R1(23) = .54 R1(24) = .61
K = .78 K = .84 K = .79

Mathematics Subjects

A. *Zero-order correlations:*

	2	3	4	5
1. G. P. A. (Math.)......	.51 ± .05 K = .86	.43 ± .05 K = .90	.41 ± .05 K = .91	.46 ± .05 K = .89

B. *Partial correlations:*

r12.5 = .30 r15.2 = .14 r12.3 = .33 r12.4 = .36

C. *Multiple correlations:*

R1(25) = .52 K = .85 R1(23) = .52 K = .85 R1(24) = .52 K = .85

Social Science Subjects

A. *Zero-order correlations:*

	2	3	4	5
1. G. P. A. (Soc. Scien.)..	.56 ± .05 K = .83	.40 ± .05 K = .92	.51 ± .05 K = .86	.52 ± .05 K = .85

B. *Partial correlations:*

r12.5 = .32 r15.2 = .21 r12.3 = .43 r12.4 = .37

C. *Multiple correlations:*

R1(25) = .56 K = .83 R1(23) = .54 K = .84 R1(24) = .61 K = .79

Physical Science Subjects

A. *Zero-order correlations:*

	2	3	4	5
1. G. P. A. (Phys. Scien.).	.53 ± .05 K = .85	.45 ± .05 K = .89	.60 ± .04 K = .80	.55 ± .05 K = .84

B. *Partial correlations:*

r12.5 = .22 r15.2 = .28 r12.3 = .34 r12.4 = .25

C. *Multiple correlations:*

R1(25) = .58 K = .81 R1(23) = .52 K = .85 R1(24) = .64 K = .77

Biological Science Subjects

A. *Zero-order correlations:*

	2	3	4	5
1. G. P. A. (Biol. Scien.)..	.56 ± .05 K = .83	.45 ± .05 K = .89	.48 ± .05 K = .88	.52 ± .05 K = .85

B. *Partial correlations:*

r12.5 = .32 r15.2 = .21 r12.3 = .39 r12.4 = .39

C. *Multiple correlations:*

R1(25) = .58 K = .81 R1(23) = .54 K = .84 R1(24) = .59 K = .81

Modern Language Subjects

A. *Zero-order correlations:*

	2	3	4	5
1. G. P. A. (Mod. Lang.)..	.63 ± .04 K = .78	.42 ± .05 K = .91	.50 ± .05 K = .87	.57 ± .05 K = .82

B. *Partial correlations:*

r12.5 = .39	r15.2 = .22	r12.3 = .52	r12.4 = .47

C. *Multiple correlations:*

R1(25) = .65	R1(23) = .63	R1(24) = .65
K = .76	K = .78	K = .76

FINE ARTS THEORY SUBJECTS

A. *Zero-order correlations:*

	2	3	4	5
1. G. P. A. (F. A. Theo.)..	.32 ± .10	.33 ± .10	.38 ± .10	.44 ± .09
	K = .95	K = .94	K = .93	K = .90

B. *Partial correlations:*

r12.5 = .004	r15 2 = .32	r12.3 = .09	r12.4 = .19

C. *Multiple correlations:*

R1(25) = .44	R1(23) = .34	R1(24) = .41
K = .90	K = .94	K = .91

FINE ARTS PRACTICE SUBJECTS

A. *Zero-order correlations:*

	2	3	4	5
1. G. P. A. (F. A. Pract.)..	.16 ± .10	.08 ± .10	.09 ± .10	.29 ± .10
	K = .99	K = .99	K = .99	K = .96

B. *Partial correlations:*

r12.5 = .04	r15.2 = .24	r12.3 = .17	r12.4 = .13

C. *Multiple correlations:*

R1(25) = .30	R1(23) = .24	R1(24) = .19
K = .95	K = .97	K = .98

CONCLUSIONS

No correlations reported are sufficiently significant to give a highly reliable index of prediction. If, on the other hand, we wish to make a dichotomous forecast, that is, to predict whether a certain group will pass or fail, having given test scores, our attempts will not be entirely wasted. A coefficient of .60 has a 20 percent value of improvement over the best guess. But when we are concerned with predetermining performance according to two levels of achievement we already have a 50 percent average of correct placement. Hence, the value of the statistical data presented depends upon the use we intend for them.

There seems to be no great differences in the various coefficients for the separate subject groups. No one group of courses has a decided advantage in correlating higher with the tests. Two exceptions to this statement are to be found. They are the groups of coefficients involving theory and practice subjects in the School of Fine Arts. The number of cases involved (40) is partly responsible for the decided lower coefficients. The difference between the correlations between practice and theory subjects is interesting. It seems that the abilities measured by the tests are used least of all in practice courses such as piano, voice, violin, freehand drawing and nature sketches. Courses of a more theoretical nature parallel more closely what the tests measured.

A statement concerning the value of the Reading Examination must be made in order to evaluate it in terms of its predictive value. The least we

can say concerning the Minnesota Reading Examination is that it is the best single predictive measure. Further, multiple correlations using the Psychological Examination with the Reading Examination gave coefficients of only slight improvement over the zero-order coefficients. The following statement seems to supply the reason for the lack of improvement in the multiple coefficients. When two variables correlate rather constantly with a criterion (G. P. A.) and significantly with one another, any multiple coefficient of correlation with the criterion is only a slight improvement over the zero-order coefficient of the criterion and either of the variables, since the intercorrelations bear out the fact that the two tests measure one and the same ability to a marked degree.

The Effect of Subcutaneous Injections of Antuitrin-S on the Anoestrous Male Ground Squirrel

(ABSTRACT)

BURTON L. BAKER, Kansas State College, Manhattan, Kan.

Antuitrin-S is a commercial extract (Parke, Davis & Co.) which contains the gonadotropic substance of human pregnancy urine. Anoestrous male ground squirrels, *Citellus tridecimlineatus arenicola* (Howell), were injected with five rat units of antuitrin-S daily until administered twelve or sixteen times. The following effects on the genitalia were observed. The testes partially descended into the scrotum and decidedly increased in size and weight as shown by statistical treatment. The enlargement of the gonads resulted chiefly from an increase in size of the seminiferous tubules. Spermatogenesis was induced from the primary spermatocyte spireme stage of anoestrus to the formation of spermatozoa in one third of the cases. All experimental animals underwent varying degrees of accelerated spermatogenesis. The seminal vesicles, Cowper's and prostate glands increased noticeably in size and weight and in secretory activity. This indicated that the testes had been stimulated to secrete the male hormone. Exclusive of a possible hypertrophy of individual cells, there was no visible change in the interstitial tissue of the gonads.

A Key to the Lizards of the United States and Canada

CHARLES E. BURT, Southwestern College, Winfield, Kan.

PREFACE

The following key is intended to give a concrete diagnosis, which may be applied in a convenient manner to each lizard that inhabits the United States or Canada. If this makes it easier for naturalists to make correct identifications, or if general research on lizards is stimulated by this action, practical ends are served.

The following key is based very largely on the writer's personal comparison of specimens in various collections, with special reference to those in the United States National Museum and the California Academy of Sciences. All genera have been examined critically. The herpetological literature has yielded much of value in the way of pointing out the differential characteristics of various forms, and the present writer, like any other who undertakes a similar problem in the biological field, finds himself deeply indebted to contemporary and previous workers. Cope and Van Denburgh merit special mention here.

This key is purely artificial, being arranged for the convenience of its users, and not even a family sequence is maintained in the text. The ranges have been prepared (1) from published records, (2) from unpublished records held by the writer, and (3) from records verified by reliable herpetologists in recent correspondence. The known distribution of each species and subspecies is indicated, but future extensions of these limits (especially slight ones) may be expected.

As Blanchard has stated in his useful "Key to the Snakes of the United States, Canada, and Lower California," a species is conceived to be a "population of similar individuals of similar habits, freely interbreeding and maintaining a high degree of constancy in most superficial as well as in all fundamental details throughout a generally considerable area." An unusual local emphasis on minor features is common, but it is not considered of taxonomic importance in separating species and subspecies. A subspecies is of the same nature as a species, except that it actually or potentially intergrades with members of one or more adjacent populations in areas where the two or more ranges involved approach or overlap. The intermediate zone of apparent intergradation delineated for two subspecies is often narrow, especially in regions like the Great Basin and the West Coast where sharp contrasts in environments are frequently presented, but the zone of intergradation may be wider in certain instances. It is often no easy task to apply the above criteria for the recognition of species and subspecies in the actual study of specimens from diverse areas, as any systematist knows.

Common names are used to accompany scientific names throughout the following key.

The scientific name of an animal is the same throughout the world, but the common name often varies with the locality or language.

Standardized common names have been applied by the general English-speaking public to many lizards (such as "horned toads" for the lizards of the genus *Phrynosoma*), while many less-known forms have been given more or less appropriate names by specialists. The present list represents an attempt

to apply the most characteristic and most widely used common name to each lizard involved. In some cases obscure or inappropriately named forms have been somewhat arbitrarily named (or renamed) here in the interest of consistency. Various correspondents, particularly those in California and the Southwest, have offered valuable suggestions. Dr. Joseph Grinnell and others at the Museum of Vertebrate Zoölogy of the University of California are followed, for instance, in reserving the cognomen "swift" for higher vertebrates, and in applying other appropriate names to the lizards called "swifts" by Ditmars and his followers.

The key in its present form is made possible through the coöperation of many institutions and individuals. The illustrations have been prepared with the aid of a substantial grant from the National Research Council. Constructive criticisms have been offered by Dr. Frank N. Blanchard, Mr. L. M. Klauber, Dr. Jean M. Linsdale, Dr. F. C. Gates, Dr. E. R. Hall and others. The following text figures were drawn by Dr. Doris M. Cochran: Nos. 2, 5-7, 17-18, 20-32, 36, 42-43, 52-53, 56-60, 62-63, and 68-71. The remaining figures were prepared through the coöperation of Mr. Albert A. Heinze, of St. Louis (Nos. 1, 3-4, 8-16, 19, 33-35, 39-41, 44-51, 54-55, 61, and 64-67). Through the courtesy of Mr. Hobart M. Smith, the drawings Nos. 37-38 of *Coleonyx* were copied (by Mr. Heinze) from the original sketches for his published plate (1932). The preliminary critical work on the text of this key was done at the United States National Museum during June, 1932, where facilities for the study of practically all of the forms (including many types) were provided through the kindness of Dr. Leonhard Stejneger and Dr. Doris M. Cochran. Moreover, an extensive series of North American lizards was loaned by the United States National Museum for use in checking the key during periods of revision extending from the academic year 1932-1933 until the present time (1935). The writer is likewise grateful to Mr. Joseph R. Slevin, of the California Academy of Sciences, and to Dr. Joseph Grinnell, of the Museum of Vertebrate Zoölogy of the University of California, for courtesies rendered in connection with the examination of certain western lizards in California during August, 1932.

GLOSSARY

(See Figure 1 for illustration of terms dealing with the scales of the head)

Acuminate. Drawn to a point.

Appressed limbs. Arms and legs extended toward each other at the sides.

Bands. Usually applied to wide strips of color of considerable length, with especial reference to dark layers.

Base of tail. Region opposite posterior margin of thigh.

Body length. Tip of snout to anus.

Canthus rostralis. Real or imaginary line connecting superciliary ridge at outer edge of supraocular area with tip of snout.

Denticulations. Tooth-like projections.

Femoral pores. Glandular, rounded openings, which are arranged in single longitudinal series on the lower surfaces of the thighs of certain lizards.

Frontal. A median plate or series of scales between the eyes of various reptiles. The frontal scales of lizards are roughly opposite the frontal bones of the skull.

Fronto-parietal. One or two median scales which appear on top of the head between the parietal and frontal scutes of certain lizards.

Ground color. Predominant or basic color in the color pattern.

Gular. Throat region.

Head width. Measurement of head at widest point, usually at angle of jaws behind eyes.

Imbricate. Overlapping like the shingles on a roof.

Interparietal. Median parietal scale.

Keeled. With a median longitudinal or diagonal ridge.

Labial. Pertaining to the lips; the upper and lower labial scales border the mouth opening laterally.

Lines. Usually applied to narrow dark longitudinal markings of considerable length.

Mental. Scale at tip of chin.

Nasal. Scale in which the nostril lies. If the nasal plate is divided by a vertical suture, the anterior half is called the "anterior nasal" and the posterior half is the "posterior nasal," or "postnasal."

Occipital. Pertaining to the dorsal base of the skull, as (1) occipital spines of "horned toads," or (2) occipital scales of most lizards. Occipital scales, when present, are usually larger than the scales of the back but smaller than the forelying parietal scales.

Occiput. Back of head, see occipital.

Parietal. Dorsal area in front of occiput and back of the level of the eyes. The parietal scales are roughly opposite the parietal bones of the skull.

Plate. Large flat scale.

Posthumeral. Pertaining to the arm pit; axillary.

Postanal plates. Subcaudal scales just back of anus. A few of these scales are decidedly enlarged in the adult males of certain lizard species.

Postmental. Chin-scale or scales just behind mental plate.

Postnasal. See nasal.

Reticulation. Network.

Rostral. Scale at tip of snout.

Scales from occiput to base of tail. Transverse series of scales, counted along middorsal line from region opposite hinder margin of the thighs forward to the hindermost of the large scales on top of the head.

Scale rows. Longitudinal series of scales, counted best in a circle around the middle of the body.

Scute. Large flat scale.

Spinose. With sharp, projecting points, spiny.

Streak. Dull or diffused stripe, line or band.

Stripes. Usually applied to narrow light markings of considerable length, especially to longitudinal ones.

Subcaudal scales. Scales on the under surface of the tail.

Superciliary ridge. Outer border of supraocular area.

Supraoculars. Scales above eye on top of head, usually enlarged and plate-like, often forming a convex area; see supraorbital.

Supraocular granules. Small scales separating enlarged supraocular scales from the large median head plates in various lizards.

Supraorbital. Pertaining to the space above the eye, see supraoculars.

Suture. Point of union between two scales.

Tail length. Anus to tip of tail. Since many lizard tails are lost and regenerated later, to a greater or lesser degree, it is obvious that maximum tail measurements may be obtained in perfect specimens only.

Tympanum. Ear drum membrane, at the ear opening.

Vertebral. Pertaining to the vertebral column; middorsal.

A KEY TO THE LIZARDS OF THE UNITED STATES AND CANADA

The arrangement adopted in this key was selected after considerable hesitation. It is the standard spread dichotomous form made so familiar to American biologists by its adoption in the various editions of Asa Gray's classic "Manual of Botany" and likewise to the herpetologists of the world through its employment by John Edward Gray and G. A. Boulenger in their widely read and fundamentally valuable catalogues of collections of various groups of amphibians and reptiles in the British Museum of Natural History. The spread dichotomous key has each entry separated from its alternative by a greater or lesser distance (which is set off by appropriate indentations), but the two alternatives of a given set always appear at the same perpendicular level on the page. A disadvantage of this type of arrangement as compared with that of the closed dichotomous key, lies in the fact that the first alternative may be hurriedly accepted without the proper consideration of its, perhaps distant, mate. However, as one becomes more and more familiar with the context of the spread dichotomous key, its more obviously displayed sections appear as units which may be discerned and perused at a considerable saving of time. Those not thoroughly familiar with the key should trace each specimen from the beginning and they should always *read both alternatives.* A hand lens or binocular microscope is helpful in studying details mentioned in the key and the use of one of these instruments is recommended in most cases.

It may be remarked here that certain species and subspecies are highly variable while others are not. The plastic forms may show such wide ranges of structural variation that certain examples of a species may identify on either side of an alternative. This is known as double-keying. If an intermediate example is used in these cases, it should identify either way. By double-keying, certain types (such as the old males or the young) can be correctly identified with ease and thus eliminated from consideration, while the more difficult material is left for identification at another place. Fortunately most forms are not variable enough to necessitate double-keying.

When studying alternatives, reference to the illustrations and glossary, when necessary, will be of aid. The scientific name of any known lizard of the United States or Canada may be found by selecting the correct one of the two alternatives that bear number "1" at the beginning of the key and then repeating the operation in regard to the next higher pair of numbers (which appears at the first indentation level below) until the correct identification, the known range, and the common name of the species or subspecies under consideration is revealed.

1. Legs absent.
   2. Ear opening distinct; eyes and eyelids well developed (Fig. 2). Joint-lizard, or "glass snake."....................*Ophisaurus ventralis* (Linné).
   (Eastern United States, from Virginia and Florida west to Wisconsin, Kansas, and New Mexico, and south into Mexico.)

A KEY TO THE LIZARDS OF THE UNITED STATES AND CANADA—CONTINUED

2. **Ear opening concealed or absent; eyes absent or weakly developed (Fig. 3).**
   3. **Body scales overlapping like the shingles on a roof (Fig. 4); body either with prominent dark longitudinal lines or black above. Footless lizards.**
      4. **General color usually silvery gray, olivaceous, or tan-tinted; back showing three or more longitudinal dark lines. Silvery footless lizard.** ***Anniella pulchra*** **Gray.**
      (Coastal strip and adjacent eastern areas, in central and southern California, south into Lower California, Mexico.)
      4. **General color deeply shaded with black or blackish brown; back sometimes without dark lines. Black footless lizard.** ***Anniella nigra*** **Fischer.**
      (Monterey county region on the west coast of California.)
   3. **Body scales not overlapping (Fig. 3); body rose-colored or pinkish in life (white in preservative), without extensive brown or black markings. Florida worm lizard** .... ***Rhineura floridana*** **(Baird).**
   (Florida.)

1. **Legs present.**
   2. ***Exactly*** **six or eight longitudinal rows of large square or rectangular ventral plates present on the lower surface of the body, these in distinct contrast with the granular scales on the lower sides and back (Fig. 5); head plates and tail scales always large (Fig. 8).**
      3. **Ventral plates in only six full-sized longitudinal rows; an additional outer row on each side noticeably reduced in size. European wall lizard (introduced)** .... ***Lacerta melisellensis fiumana*** **Werner.**
      (Vicinity of Philadelphia, Pennsylvania.)
      3. **Ventral plates in eight full-sized longitudinal rows (Fig. 5). Race-runners and whiptail lizards.**
         4. **Two median, unpaired plates present in the region above and between the eyes (*i. e.*, with a single frontoparietal plate) (Fig. 10). Orange-throated race-runner** .... ***Cnemidophorus hyperythrus hyperythrus*** **Cope.**
         (Southern California, south into Lower California, Mexico.)
         4. **Only one median, unpaired plate present in the region above and between the eyes (with a longitudinally divided or double frontoparietal plate) (Fig. 8).**
            5. **Back of forearm beyond (or distal to) elbow covered with granules of about the same size (the center ones sometimes very slightly enlarged).**
               6. **Sides always extensively tessellated, having irregular light and dark markings and often crossbars; upper part of back (especially in young) showing about four more or less irregular longitudinal light stripes (although the number may vary from none to many); under surface either white, slate-colored, coal black, or black spotted; never with (1) a straight or perfectly continuous lower lateral stripe along the flanks and never with (2) extensive indications of such striping. Desert whiptail, or tiger lizard.** ***Cnemidophorus tessellatus tessellatus*** **(Say).**
               6. **Otherwise.**
               (Western North America from Oregon southeast to the Panhandle of Texas, and south into Mexico.)
                  7. **Never with light spots in the dark fields between the light stripes; six narrow light stripes and a fainter, widened, yellowish vertebral band or streak usually present; never with seven narrow stripes; ventral surface never with blue-black or black unless discolored by preservatives. Six-lined race-runner** .... ***Cnemidophorus sexlineatus sexlineatus*** **(Linné).**

(Eastern United States west to the Rocky Mountains, north at least as far as New Jersey and Wisconsin, south to the Panhandle of Texas, and southeast to the Gulf Coast above the mouth of the Rio Grande.)

7. Not with the above combination of characters. Specimens traced through to this point should be referred *through* alternative No. 5 *immediately below* to No. 6 for identification.

5. Back of forearm beyond (or distal to) elbow showing a central patch of decidedly enlarged plate-like scales (Fig. 9).

6. Ventral surface with a greater or lesser development of blue-black pigment; throat often pink. Spotted race-runner.
(Oklahoma and Texas, south into Mexico.) *Cnemidophorus sexlineatus sackii* Wiegmann.

6. Ventral surface white, slaty, or with light pigmentation only, unless discolored by preservatives.

7. Counting only light stripes of approximately equal intensity and width, back either (1) with an *odd* number of stripes, (2) with an irregular pattern and an uncertain number of stripes, or (3) with no stripes at all; narrow vertebral stripe sometimes (but by no means always) incomplete for part of length. Sonoran race-runner.......*Cnemidophorus sexlineatus perplexus* Baird and Girard.
(Sonoran region in Arizona, southern Utah and western Colorado, southeast into the Pecos region of Texas, and south into Mexico.)

7. Counting only light stripes of equal intensity and width, back with an even number of stripes; a comparatively faded, yellowish, widened, vertebral streak often (but by no means always) present above.

8. The inner pair of distinct stripes designated above (and bordering the vertebral area) closer to each other than to the stripes below them. Sonoran race-runner..*Cnemidophorus sexlineatus perplexus* Baird and Girard.
(For range, see above under 7.)

8. The pair of distinct stripes bordering the vertebral area closer to the stripes below them than to each other. Spotted race-runner.
(Oklahoma and Texas, south into Mexico.) *Cnemidophorus sexlineatus sackii* Wiegmann.

2. Scutellation varied but not as above (Figs. 6-7, 15-16).

3. "Horned toads" with sides and back of head showing either (1) sharp or blunt horns (Figs. 12-14, 17-18), or (2) practically no horns (Fig. 19); tail usually shorter than the body, often very short; body always dorsoventrally flattened or widened.

4. Nostrils situated above the real or imaginary canthus rostralis line (which connects the supraorbital ridge with the tip of the snout) on each side (Figs. 13-14). Use dorsolateral view.

5. Four large *closely-set* occipital spines (or horns) on back of head (Fig. 14). Regal "horned toad"...........*Phrynosoma solare* Gray.
(Southern Arizona, south into Mexico.)

5. Only two occipital spines on back of head, these with a space or tubercule between them (Figs. 13, 17-18).

6. Ear opening well-developed; tympanum not covered with flesh and scales, but often in a large vertical depression (which may be more or less concealed by skin folds).

7. Peripheral fringe of two series of thin, elongate, flattened spines on each side of body; ventral scales usually keeled (Fig. 15). Texas "horned toad" ....*Phrynosoma cornutum* (Harlan).
(Great Plains in Colorado, Kansas and Arkansas, thence southwest from these states through Texas, New Mexico, and southeastern Arizona into Mexico.)

A KEY TO THE LIZARDS OF THE UNITED STATES AND CANADA—CONTINUED

7. Peripheral fringe of only one series of small elongate, flattened spines on each side of body, this poorly developed; ventral scales smooth (Fig. 16). Desert "horned toad"............ *Phrynosoma platyrhinos* Girard.
(Great Basin of the West, from southern and eastern California north to southeastern Washington, southeast through Idaho, western Utah and Arizona, south into Mexico.)

6. Ear opening absent or vestigial; tympanum covered with flesh and scales.

7. Terminal portion of tail more or less rounded; occipital spines moderately developed, about as long as temporal spines or a trifle longer. Round-tailed "horned toad"............ *Phrynosoma modestum* Girard.
(Western Texas, west to southeastern Arizona, south into Mexico.)

7. Terminal portion of tail conspicuously depressed or flattened; occipital spines well-developed, decidedly longer than temporal spines. Flat-tailed "horned toad"............ *Phrynosoma m'callii* (Hallowell).
(Southeastern California and southwestern Arizona, south into Mexico.)

4. Nostrils situated on, about on, or somewhat below the canthus rostralis line on each side (Figs. 12, 17-18). Use dorsolateral view.

5. Head spines rudimentary, short, tuberculate or pyramidal, often inconspicuous (Figs. 12, 19).

6. Ventral scales keeled (Fig. 15). Stump-horned "horned toad"............ *Phrynosoma ditmarsi* Stejneger.
(Probably southern Arizona, south into Mexico.)

6. Ventral scales smooth (Fig. 16).

7. Flat top of head often (but not always) uniform in color (*i. e.*, cephalic tubercles without deep reddish brown or black tips, and with no dark color markings or contracted pigmented areas); lateral superciliary ridge not noticeably rounded back of point above center of eye (Fig. 12); average size larger (body of adults often over 60 mm. in length); scales on top of head flatter (on the average), less tuberculate; posterior border of supraocular semicircles often well defined. A poorly differentiated subspecies. Shorthorn "horned toad"............ *Phrynosoma douglassii hernandesi* (Girard).
(Western Texas, north through western Kansas into western South Dakota, thence west and somewhat north through Montana to Idaho, and south through Nevada and Arizona into Mexico.)

7. Flat top of head usually not uniform in color; lateral superciliary ridge often noticeably rounded back of point above center of eye (Fig. 19); average size smaller (adults usually less than 60 mm. in length); scales on top of head more tuberculate; posterior border of supraocular semicircles often poorly defined. A poorly differentiated subspecies. Pigmy "horned toad."
Phrynosoma douglassii douglassii (Bell).
(West coast of North America from central California north to Washington, east into Idaho.)

5. Head spines well-developed, elongate, conspicuous (Figs. 13, 17-18).

6. Scales usually much enlarged on the inner margins of the supraocular semicircles, just adjacent to the frontal or interorbital area (Fig. 17); head scales usually larger than in the subspecies below, and often smooth or nearly so; a poorly differentiated subspecies. Southern yellow-breasted "horned toad"............ *Phrynosoma coronatum blainvillii* Gray.
(Southern California, south into Lower California, Mexico.)

A KEY TO THE LIZARDS OF THE UNITED STATES AND CANADA—CONTINUED

6. Scales usually not much enlarged on the inner margins of the supraocular semicircles, just adjacent to the frontal or interorbital area and (on the average) but slightly centrally (Fig. 18); head scales usually smaller than in the subspecies above, and often with numerous ridges and granulations; a poorly differentiated subspecies. Northern yellow-breasted "horned toad."
Phrynosoma coronatum frontale Van Denburgh.
(Eastern Montana and probably west to the Pacific Ocean, southwest as far as Kern county in south-central California.)

3. Not with the above combination of characters (Figs. 1, 11, 20-21, 29-30, 35-36, 44-51, 70-71).
4. Limbs vestigial, extremely minute (Fig. 20) and with only one or two digits; body elongate, cylindrical. Burrowing skink.
(Central Florida.) *Neoseps reynoldsi* Stejneger.
4. Limbs completely developed (Fig. 21, 40-41, 54-55); digits normally five, with or without distal expansions or pads.
5. Digits noticeably dilated or expanded at some point away from the base (Figs. 25-28).
6. Eyelids developed, both above and below eye (Fig. 29); tail slender, tapering, not particularly fragile and not constricted at base; throat-fan often discernible; skin tough. Anoles, or New World "chameleons."
7. Body and tail without a median dorsal ridge or keel; tail rounded, without rings or with only inconspicuous rings of larger scales (Fig. 32). American "chameleon" .... *Anolis carolinensis* Voigt.
(Southeastern United States from North Carolina west to Oklahoma, and south across the Rio Grande into Mexico.)
7. Tail with a median dorsal ridge or keel that extends forward on the back for a greater or lesser distance; tail strongly compressed from the sides, usually with conspicuous rings of larger scales that are separated by alternate belts of smaller ones (Fig. 31). Ring-tailed anolis .... *Anolis stejnegeri* Barbour.
(Key West, Florida.)
6. Eyelids not developed, eye exposed or set in a rounded capsule (Fig. 30); tail thickened, fragile, often constricted at base; never with a throat-fan; skin soft. Geckos.
7. Maximum digital expansion not at tip of digit (Fig. 26); terminal digital pads absent. European gecko (introduced).
(Key West, Florida.) *Hemidactylus turcicus* (Linné).
7. Maximum digital expansion at tip of digit where large digital pads are found (Figs. 27-28).
8. Terminal digital pads not rounded, split into two elements along the median line (Fig. 27). Warty gecko.
(Southeastern California, south into Mexico.) *Phyllodactylus tuberculosus* Wiegmann.
8. Terminal digital pads rounded, not split along the median line (Fig. 28).
9. Scales on back larger, flattened, overlapping, usually with median longitudinal keels (Fig. 33). Reef gecko.
(Southern Florida.) *Sphaerodactylus notatus* Baird.
9. Scales on back small, granular or beaded, not overlapping, smooth (Fig. 34). Greater antillean gecko (introduced).
(Key West, Florida.) *Sphaerodactylus cinereus* Wagler.
5. Digits normal, tapering or of even width from base toward tip (Figs. 22-24).

A KEY TO THE LIZARDS OF THE UNITED STATES AND CANADA—CONTINUED

6. Scales on top of head *finely* granular (Fig. 36); skin soft; tail fragile and always constricted at base; claws very small; body never with longitudinal markings. Desert geckos.
   7. Preanal pores 4-6, not in contact medially; cloacal bones, or their analogues, broad at tip (Fig. 37). Texas desert gecko. ***Coleonyx brevis*** **Stejneger.**
      (Southeastern New Mexico and southern and central Texas, south into Mexico.)
   7. Preanal pores 6-10, in contact medially; cloacal bones, or their analogues, pointed and straight (Fig. 38). Sonoran desert gecko. ***Coleonyx variegatus*** **(Baird).**
      (Southern Utah, Nevada and California, south into Mexico.)
6. Scales on top of head large or coarsely granular (Figs. 11. 35, 44-45, 61); skin tough; tail usually not noticeably constricted at base.
   7. Large dorsal scales strongly convex or beaded, separated from each other by granules (Fig. 39); body mottled with conspicuous, irregular patches of bright orange and shiny black; tail unusually thick and heavy; size large; poison glands and grooved poison-fangs (teeth) in lower jaw. Sonoran gila monster............***Heloderma suspectum*** **Cope.**
      (Southern Utah and Nevada, south through Arizona into northern Mexico.)
   7. Not with the above combination of characters.
      8. Eyelids not developed, eye exposed or set in a rounded capsule (Fig. 30); pupil of eye vertical. Night lizards.
         9. Large ventral plates in 16 or more longitudinal rows (at widest part of body). Island night lizard, ***Xantusia riversiana*** **Cope.**
            (Islands off the coast of southern California.)
         9. Large ventral plates in less than 16 longitudinal rows.
            10. Large ventral plates in 14 longitudinal rows, the outer ones often reduced in size. Spotted night lizard. ***Xantusia henshawi*** **Stejneger.**
                (Southern California, south into Lower California, Mexico.)
            10. Large ventral plates in 12 longitudinal rows, the outer ones often reduced in size (Fig. 6).
                11. Less than 42 series of small scales usually present across the back, counting from the outer row of large ventral plates on one side to the corresponding row of scales on the other side. Desert night lizard.......***Xantusia vigilis*** **Baird.**
                    (Western Arizona, southern Nevada and southern California, south into Lower California, Mexico.)
                11. More than 42 series of small dorsal scales usually present across the middle of the back. Arizona night lizard.
                    (Central Arizona.) ***Xantusia arizonae*** **Klauber.**
      8. Eyelids developed, both above and below eye (Figs. 29, 44-45, 46-47).
         9. Femoral pores absent (Fig. 41).
            10. A prominent skin fold between the limbs on each side, this producing a shallow lateral groove[1] in which many small scales are found (Fig. 43): dorsal scales sometimes keeled.

1. Appearing merely as an invertable band of small scales in certain expanded or overinjected preserved specimens. This groove expands and contracts (opens and closes) in the living animal in keeping with the respiratory movements.

11. Median frontonasal plate absent (Fig. 45) or represented by paired elements. False alligator lizard. (Sonoran region.) *Barissia levicollis* Stejneger.

11. Median frontonasal plate present, unpaired (Fig. 44). True alligator lizards.[2]

12. Dark brown or blackish ventral lines (if discernible) extending along the middle of the longitudinal rows of ventral plates (more or less dispersed or mottled in old specimens of certain species), which tend to have darker centers than edges; tail (when perfect) consisting of 114 or more whorls; iris of eye yellow and unpigmented in life (at least in the species of the West Coast); transverse color bands of back usually confluent and comparatively conspicuous, always present.

13. No weakly keeled scales on outer surface of forearm or tibia of hind leg; sometimes with black markings on the lower labials; scales at back of head smooth or nearly so.

14. Dorsal scales perfectly smooth or with only two or three vertebral rows showing weak longitudinal ridges or carinations; more than 50 transverse scale rows from ear to back of thigh. Sonoran alligator lizard. (New Mexico and Arizona, south into Mexico.) *Gerrhonotus kingii* Gray.

14. More than three rows of median dorsal scales showing weak carinations, extreme lateral scales often smooth; often less than 50 transverse scale rows from ear to back of thigh. Texas alligator lizard. (Rio Grande Valley in Texas, south into Mexico.) *Gerrhonotus infernalis* Baird.

13. Weakly keeled scales usually present on outer surface of forearm and tibia of hind leg; usually without irregular black markings on the lower labials; scales at back of head often ridged.

14. Posterior upper temporal scales usually strongly keeled (just below level of superciliary line); number of keeled dorsal scales exceeding number of smooth ventral scales in each caudal whorl from four to 10 rows behind anus. San Diegan alligator lizard................. *Gerrhonotus multi-carinatus webbii* Baird. (Central and southern California, south into Lower California, Mexico.)

14. Temporal scales all smooth or with posterior upper temporals very weakly keeled; number of keeled dorsal scales less than number of smooth ventral scales in each caudal whorl from four to 10 rows behind anus.

15. Transverse dorsal blotches on back often more than a single scale row in width, usually shading into

2. Through the courtesy of Mr. Henry S. Fitch, of the Museum of Vertebrate Zoölogy of the University of California, who has made a detailed study of the alligator lizards of the West Coast, I have a copy of his "Key to *Gerrhonotus* in Western United States and Canada" with permission to use parts of it in the present key; and this has been an invaluable aid. Mr. Fitch writes that "because of the wide range of individual variation in *Gerrhonotus* it is probably not possible to devise a workable key which every specimen will fit. Some of the characters of color pattern and keeling cannot be applied successfully to very young specimens. Eye color is a useful character only when the lizards are alive or freshly killed. The number of scale whorls on the tail is perhaps also an impractical character because of the high percentage of imperfect tails. Nevertheless, when they can be used, these characters constitute some of the most obvious and important external differences." The present arrangement of the alligator lizards is very largely that adopted by Mr. Fitch and his taxonomic conclusions are followed, since they appear to be logically derived.

A KEY TO THE LIZARDS OF THE UNITED STATES AND CANADA—CONTINUED

red or brown anteriorly; often with reddish or orange blotches on body; dark spots often present on head. Western alligator lizard........*Gerrhonotus multi-carinatus multi-carinatus* Blainville. (Sacramento Valley of California, south along the coast to Ventura county.)

15. Transverse dorsal blotches on back typically a single scale row in width, and not shading into red or brown anteriorly; no red in the general color pattern; no dark spots on head. Oregon alligator lizard ....*Gerrhonotus multi-carinatus scincicauda* (Skilton). (Southwestern Washington, south through Oregon to northwestern California.)

12. Dark brown or blackish ventral lines (if discernible) extending between the longitudinal rows of ventral plates or diffusing so as to give them dark emarginations; tail (when perfect) consisting of fewer than 114 whorls; iris of eye dark (or pigmented) in life; transverse dorsal color bands present or absent, and often (but not always) discontinuous, frequently narrowed, or irregular.

13. A very wide vertebral streak or band of light gray or tan color present on back for a width of six or eight longitudinal rows of scales; sides decidedly darker; back with or without vertebral dark spots, and usually without white-tipped scales.

14. Two middorsal scale rows of neck (about six plates back of large posterior head shields) broader than those lateral to them; dark markings on back scattered, obscure or absent. Northern alligator lizard. *Gerrhonotus coeruleus principis* (Baird and Girard). (Western coast of North America from Canada south to northern California.)

14. Two middorsal scale rows of neck usually square or narrower than those lateral to them; dark markings on back in a single row of large median blotches. San Franciscan alligator lizard. *Gerrhonotus coeruleus coeruleus* Wiegmann. (West coast of California, from Monterey county, northward to the region about San Francisco.)

13. No light vertebral band present on back; white-tipped scales often present on upper surface.

14. Lower temporal scales perfectly smooth; ground color of head and neck often contrasting with that of body. Shasta alligator lizard............................*Gerrhonotus coeruleus shastensis* Fitch. (California, northward from region about San Francisco to southwestern Oregon.)

14. Temporal scales keeled; ground color of head and neck like that of body. Mountain alligator lizard. (Sierra Nevada Mountains of California.) *Gerrhonotus coeruleus palmeri* Stejneger.

10. Sides normal, with even contour; no conspicuous skin fold below the limbs on each side; lateral groove absent; dorsal scales never strongly keeled (Fig. 42). Skinks.

11. Lower eyelid with a clear, transparent central spot (Fig. 47); body small, cylindrical; color bronze above, darker on the sides. Brown-backed skink..*Leiolopisma unicolor* (Harlan). (Eastern North America from New York to Florida, west to central Kansas, south into Mexico.)

A KEY TO THE LIZARDS OF THE UNITED STATES AND CANADA—CONTINUED

11. Lower eyelid completely covered with scales (Fig. 46).

12. Back blackish, with exactly five prominent light lines of about equal intensity and width, the vertebral stripe forking on the head; young to adult in primary stage of development. Five-lined skink. *Eumeces fasciatus* (Linné).[3]
(Eastern United States from New England west across southern Canada to northern Michigan, thence to central South Dakota, south across the Rio Grande into Mexico.[4]

12. Back otherwise; if five stripes are present, the vertebral one weaker than the others and often (but not always) not distinctly forked anteriorly.

13. Back with seven or more narrow light stripes, and nine or more dark bands (of varying size and definition). Many-lined skink .... *Eumeces multivirgatus* (Hallowell).
(Western Nebraska and probably southern Wyoming, south through New Mexico and western Texas.[4]

13. Back with fewer than seven light stripes and dark bands, or none at all.

14. Back with exactly five narrow white stripes, these (especially the dorsal one) often more or less faint and of varying width and intensities.

15. Two postmental plates present (Fig. 48).

16. Ground color of back and sides uniform or graded, dark; size small, young. Many-lined skink. (For range, see above under 13.) *Eumeces multivirgatus* (Hallowell).

16. Ground color of back lighter than that of sides; sides dark and size often larger.

17. Median subcaudal scales transversely dilated, enlarged beginning a short distance back of anus; cheeks often bulged, frequently reddish; average size larger, frequently over 65 mm. in body length. Five-lined skink, or "scorpion" in intermediate stage of color metamorphosis .... *Eumeces fasciatus* (Linné).
(Eastern United States from New England west across southern Canada to northern Michigan, thence to central South Dakota, and south across the Rio Grande into Mexico.[4]

17. Median subcaudal scales not transversely dilated or enlarged; cheeks usually normal, not particularly bulged or colored with red in most cases. Average size smaller, usually less than 65 mm. in adult body length. Sonoran stone skink. . *Eumeces callicephalus* Bocourt.[4]
(Southern Arizona, south into Mexico.)

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3. Two species of *Eumeces* (*inexpectatus* and *laticeps*) were described in 1932 (Taylor, Univ. Kansas Sci. Bull., Vol. 22, No. 13, pp. 251, 263). As stated by Stejneger and Barbour (1933, p. 80) in their check list, "the evidence thus far adduced does not support the validity of these forms." These provisional species are obviously based on *E. fasciatus* as previously defined and as the present writer conceives it after an extensive and prolonged study of the problem.

4. A previous conception of *Eumeces fasciatus* as an inhabitant of the Sonoran region is possibly based on the examination of young specimens of *E. multivirgatus* from New Mexico; or of examples of *E. callicephalus* from Arizona (see Stejneger and Barbour, 1933, p. 81). As a species, *E. callicephalus* seems very close to *E. tetragrammus*, from which it differs in having a faint and sometimes indistinct vertebral stripe that bifurcates on the head, where it is usually most distinct.

15. One postmental plate present (Fig. 49).
    16. A postnasal scale present (Fig. 50). Five-lined skink, or "scorpion."
        (For range, see above under 17.) *Eumeces fasciatus* (Linné).
    16. No postnasal scale (Fig. 51). Black skink (dark phase), or brown-banded skink (light phase). *Eumeces anthracinus* Baird.
        (Eastern United States, from Pennsylvania west to Kansas and eastern Texas.)

14. Back otherwise than with five narrow white stripes.
    15. Body with two prominent light lines and two dark bands (of different widths) on each side; vertebral and dorsolateral area usually light and marked by two narrow, sometimes obsolete dark lines. Prairie skink ....*Eumeces septentrionalis* (Baird).
        (Prairie region, Wisconsin to North Dakota, north into adjacent Canada (at least Manitoba), and south into Oklahoma and possibly Missouri.)
    15. Body otherwise.
        16. Body without regular, even-bordered longitudinal light stripes or dark bands, even at sides of head; general ground color of back light, usually rather uniform or graded olivaceous.
            17. Limbs short, not meeting on sides when appressed.
                18. Scales on sides of body usually in oblique rows, at point midway between insertions of limbs; gray or slate often (but not always) predominant in dorsal coloration; adults large, measuring over 75 mm. in body length; young examples have at least some white spotted supralabials. Gray skink, or Sonoran skink. *Eumeces obsoletus* (Baird and Girard).
                    (Sonoran and Great Plains area from the Gulf Coast of Texas north to northern Kansas and Colorado, southwest through Arizona, south into Mexico.)
                18. Scales on sides of body in parallel rows at point midway between insertions of limbs; dark or light brown usually predominant in dorsal coloration; size never extremely large, body rarely over 75 mm. from snout to anus; supralabials not spotted, never with black borders and white centers.
                    19. Foreleg extending forward to region of eye. Many-lined skink (old adult). *Eumeces multivirgatus* (Hallowell).
                        (Western Nebraska and probably southern Wyoming, south through New Mexico and western Texas.)
                    19. Foreleg not extending forward to region of eye.
                        20. Twenty-three or fewer scales around the middle of the body; adults smaller, body length not exceeding 60 mm. in most cases; body unusually slender (like

Leiolopisma unicolor). Fragile skink..........*Eumeces egregius* (Baird).
(Florida.)

20. More than 23 scales around the middle of the body; adults larger; body somewhat thickened (like *Eumeces fasciatus*).
    21. Median row of subcaudal scales usually several times broader than long, much enlarged; traces of unusually wide light stripes often present on body or head. Western skink..*Eumeces skiltonianus* Baird and Girard.
    (Western North America from southern Canada to Mexico, east as far as the Utah level, south into Lower California, Mexico.)
    21. Median row of subcaudal scales not enlarged or just slightly enlarged; traces of stripes narrow when present on body or head. Pecos skink.
    Eumeces humilis Boulenger.
    (Trans-Pecos region of Texas, south into Mexico.)

17. Limbs longer, meeting or overlapping on sides when appressed.
    18. Scales on sides of body usually in oblique rows at point midway between insertions of limbs; adults large, often measuring over 75 mm. in body length, often grayish; young with at least some white-spotted supralabials. Gray skink, or Sonoran skink.
    Eumeces obsoletus (Baird and Girard).
    (Sonoran and Great Plains area from the Gulf Coast of Texas north to northern Kansas and Colorado, southwest through Arizona, south into Mexico.)
    18. Scales on sides of body in parallel rows at point midway between insertions of limbs; adults smaller, often brown or blackish; supralabials not with black borders and white centers.
        19. Claws thickened almost to tip, sharply curved (Fig. 53); head reddish and cheeks often greatly expanded (large adult males in last stage of ontogenetic color pattern development). Five-lined skink, or "scorpion".....*Eumeces fasciatus* (Linné).
        (Eastern United States, from New England west across southern Canada to northern Michigan, thence to central South Dakota, south across the Rio Grande into Mexico.)
        19. Claws more slender, tapering, moderately curved (Fig. 52); head usually less reddish and cheeks less expanded in large adult males. Western skink.
        Eumeces skiltonianus (Baird and Girard).
        (Western North America from southern Canada to Mexico, east as far as the Utah level, south into Lower California, Mexico.)

16. Body with evident longitudinal light stripes or dark bands, at least on the head.
   17. Limbs shorter, toes of appressed limbs separated at sides for a greater or lesser distance.
      18. Usually less than 23 scales around the middle of the body; body unusually elongate (like *Leiolopisma unicolor*). Fragile skink.............. ***Eumeces egregius*** (Baird). (Florida).
      18. More than 23 scales around the middle of the body; body stouter.
         19. The two light lines on each side of the body not distinct as far as the insertion of the hind leg; lines (1) shortened, or (2) entirely wanting.
            20. Light lines distinct at least on the sides of the head, and often for a greater or lesser distance posteriorly. Short-lined skink.
            (Texas.) ***Eumeces brevilineatus*** Cope.
            20. No distinct light lines on sides of body, even the dark lateral bands sometimes obsolescent. Pecos skink.............. ***Eumeces humilis*** Boulenger.
            (Trans-Pecos section of Texas, south into Mexico.)
         19. The two light lines on each side of the body continuous and usually distinct as far back as the insertion of the hind leg (sometimes with one stripe reaching the groin while the other fades a short distance anteriorly).
            20. One postmental plate (Fig. 49) and no postnasal scale (Fig. 51); top of head without a pair of bifurcating light lines; black skink (dark phase) or brown-banded skink (light phase)................. ***Eumeces anthracinus*** (Baird).
            (Eastern United States, from Pennsylvania west to Kansas and eastern Texas.)
            20. Not with this exact combination, having (1) two postmental plates (Fig. 48) or (2) a postnasal scale (Fig. 50), *or* (3) both of these features.
               21. White dorsolateral stripes separated across the back (at a point midway between the insertions of the fore and hind limbs) by four rows of scales or less. Western skink...... ***Eumeces skiltonianus*** (Baird and Girard).
               (Western North America from southern Canada to Mexico, east as far as the Utah level, south into Mexico.)
               21. White dorsolateral stripes separated across the back by more than four rows of scales.
                  22. Top of head of uniform or graded color, and without a pair of bifurcating white lines. Texan stone skink.
                  (Texas, south into Mexico.) ***Eumeces tetragrammus*** (Baird).

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22. Top of head with a pair of more or less indistinct bifurcating light lines; starting at the occiput or posteriorly, the bifurcation skirts the outer margins of the interparietal and frontal plates and extends forward toward the tip of the snout. Sonoran stone skink.
Eumeces callicephalus Bocourt.
(Southern Arizona, south into Mexico.)

17. Limbs elongate, toes of appressed limbs meeting or overlapping at the sides for a greater or lesser distance.

18. One postmental plate (Fig. 49) and no postnasal scale (Fig. 51). Black skink (dark phase) or brown-banded skink (light phase)..........*Eumeces anthracinus* (Baird).
(Eastern United States, from Pennsylvania west to Kansas and eastern Texas.)

18. Not with this exact combination, having (1) two postmental plates (Fig. 48) or (2) a postnasal scale (Fig. 50), *or* (3) both of these features.

19. Not more than 4 longitudinal rows of scales in the vertebral area between the dorsolateral light stripes (at a point midway between the insertions of the fore and hind limbs); dorsolateral light stripes wide and conspicuous in young specimens, fading in older ones. Western skink..*Eumeces skiltonianus* (Baird and Girard).
(Western North America, from Canada to Mexico, east as far as the Utah level, south into Mexico.)

19. More than 4 longitudinal rows of scales in the vertebral area between the dorsolateral light stripes; dorsolateral light stripe fading (with trace of median dorsal light stripe frequently discernible).

20. Median subcaudal scales transversely dilated, enlarged beginning a short distance back of anus; cheeks often bulged, frequently reddish; average size larger, frequently over 65 mm. in body length. Five-lined skink, or "scorpion" in intermediate stage of color metamorphosis.
Eumeces fasciatus (Linné).
(Eastern United States from New England west across southern Canada to northern Michigan, thence to central South Dakota, and south across the Rio Grande into Mexico.)

20. Median subcaudal scales not transversely dilated or enlarged; cheeks usually normal, not particularly bulged or covered with red in most cases; average

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size smaller, usually less than 65 mm. in adult body length. Sonoran stone skink.................................*Eumeces callicephalus* Bocourt. (Southern Arizona, south into Mexico.)

9. Femoral pores present (Figs. 40, 54-55).
    10. Ear opening absent, tympanum completely concealed (Fig. 3). Sand lizards, or Holbrookias.[5]
        11. Under surface of tail with black crossbands or spots. Zebra-tailed sand lizards.
            12. With (1) no black spots on ventrolateral surface, *or* with (2) black markings situated more anteriorly and most distinct in the thoracic region where they are usually not continued high laterally. Small zebra-tailed sand lizard. (Central Texas.) *Holbrookia maculata lacerata* Cope.
            12. Distinct ventrolateral black markings on posterior half of body where they are often continued high laterally. Large zebra-tailed sand lizard..*Holbrookia texana* (Troschel). (Western Texas to Arizona, south into Mexico.)
        11. Under surface of tail without black crossbands or spots.
            12. No black spots or bars on ventrolateral surface. Small zebra-tailed sand lizard. (Central Texas.) *Holbrookia maculata lacerata* Cope.
            12. Black spots or bars present on ventrolateral surface.
                13. Tail shorter than body (snout to anus) in most females[6] and in about two thirds of males[6]; usually from 8 to 15 femoral pores present, average about 12; scalation coarser. A poorly differentiated subspecies. Common spotted sand lizard.....................................*Holbrookia maculata maculata* Girard. (Prairie region and Great Basin, from Texas north through eastern Kansas to southern South Dakota, then west into Wyoming and southwest through Utah and Arizona into Mexico.)
                13. Tail longer than body in most males and in at least two thirds of females; usually from 12 to 20 femoral pores present, average about 16; scalation finer. A poorly differentiated subspecies. East Texas sand lizard. (Eastern Texas.) *Holbrookia maculata propinqua* Baird and Girard.
    10. Ear opening present, distinct (Figs. 35, 50-51, 61).

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5. I follow Van Denburgh (1922) in the tentative inclusion of a number of Southwestern forms of this genus under one head. The published data, and my tentative examination of representatives of the populations concerned, do not appear to give sufficient grounds for the recognition of such forms as *campi*, *pulchra*, *elegans*, and *approximans*; yet a perceptible differentiation (perhaps the evidence of local phases), can be seen in certain areas. It is clear that relative tail length is a poor diagnostic character when used alone, for like the color pattern it is subjected to wide individual variation (and frequently to marked sexual dimorphism). Further study of this problem is in progress. The recently described *H. propinqua stonei* Harper (Proc. Biol. Soc. Wash., Vol. 45, 1932, p. 15) cannot, in my opinion, be maintained as a valid form.

6. Male sand lizards show enlarged postanal scales at the base of the tail (Fig. 55) while the females do not display this feature (Fig. 54).

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11. One row of median dorsal scales strongly enlarged, keeled, forming a very low (but obvious) vertebral ridge or crest; scales on each side of vertebral line smaller, uniform or graded in size (Fig. 58).
    12. Rings of scales on anterior half of tail strongly spinose, the sharp points extending backward. Mexican spiny-tailed iguana .... *Ctenosaura acanthura* (Shaw).
    (Sonoran region, possibly including southern Arizona.)
    12. Rings of scales on tail keeled but not spinose, without very obviously projecting points. Short-headed sand iguana. *Dipsosaurus dorsalis dorsalis* (Baird and Girard).
    (Great Basin of the West from southern Nevada and Utah south through Arizona and southeastern California into Mexico.)
11. Dorsal scales usually (1) uniform or graded in size, but sometimes (2) with several median longitudinal rows of enlarged series; no vertebral ridge or crest formed by one row of overdeveloped scales (Figs. 56-57).
    12. Rostral plate divided, snout without a single terminal scute (Fig. 59); ear opening with strong anterior denticulations (Fig. 61); adults very large; tail scarcely longer than body; vertebral depression evident; always with 12 or more than 12 upper labial scales to below center of eye. Chuckwalla............ *Sauromalus obesus* (Baird).
    (Southwestern Utah and southern Nevada, south through Arizona and southern California into Mexico.)
    12. Rostral plate entire, snout with a single terminal scute (Fig. 60).
        13. Back and sides never entirely covered with flat, strongly keeled, overlapping scales.
            14. Upper labial scales strongly oblique and definitely overlapping; sutures between upper labial scales not vertical, nearly vertical, *or* rounded (Fig. 65).
                15. Digits with conspicuous fringes of soft, projecting, pointed scales (Fig. 22). Ocellated sand lizard. (Sonoran region of California and Arizona, south into Mexico.) *Callisaurus notatus* (Baird).
                15. Digits with inconspicuous fringes of minute projecting scales, or without such fringes (Fig. 24). Desert gridiron-tailed lizard .... *Callisaurus draconoides ventralis* Hallowell.
                (Great Basin of the West, Utah and Nevada, south into Arizona and Southern California, thence into Mexico.)
            14. Upper labial scales not strongly oblique and not overlapping; sutures between upper labial scales vertical or nearly vertical, *or* rounded (Fig. 64).
                15. Nine or more than 9 upper labial scales to below center of eye.
                    16. A double black collar normally present on the shoulders. Collared lizard, or mountain boomer. *Crotaphytus collaris* (Say).
                    (Western North America, north as far as Oregon, Colorado, and Missouri, thence southwest through Arkansas into Texas, and south into Mexico.)
                    16. No black collar on the shoulders; dark markings on the anterior part of the back of the same general type as those found posteriorly.

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17. Back with *or* without transverse light markings, often with numerous rounded, dark brown spots, which usually do not show very distinct light borders.
   18. Greatest width of head usually less than distance between nostril and ear opening. Common leopard lizard....................*Crotaphytus wislizenii* Baird and Girard. (Western Texas northwest into Idaho and Oregon, south through the Great Basin into Mexico).
   18. Greatest width of head usually equal to, almost equal to, or greater than distance between nostril and ear opening: occidental. Short-nosed leopard lizard. *Crotaphytus silus* Stejneger.[7] (Central California, west of the Sierra Nevada range.)

17. Back usually with no trace of transverse light markings; ground color of back broken by coarse, irregular light reticulations; a part of this network forms *distinct* white edges around large dark brown dorsal spots. Reticulated lizard........*Crotaphytus reticulatus* Baird. (Texas.)

15. Less than 9 upper labials from rostral to below center of eye (Fig. 70).
   16. A confluent, narrow, conspicuous band of *intense* black crossing from shoulder to shoulder; tail with conspicuous alternating dark and light bands. Giant boulder uta. *Uta mearnsi* Stejneger. (Eastern slope of the Coast Range of southern California, south into Lower California, Mexico.)
   16. No confluent, narrow band of intense black crossing from shoulder to shoulder; black collar, if present, confined to the lateral area on each side; tail with *or* without crossbars.
      17. Dorsal scales of sharply contrasting sizes; three or more rows of scales much enlarged at or just lateral to the vertebral line (Figs. 56, 66-67).
         18. Longitudinal series of large dorsal scales on posterior half of back not separated or scattered by vertebral series of smaller scales (Fig. 67); tail unusually long. Long-tailed uta...*Uta graciosa* (Hallowell). (Southern Arizona, southern Nevada and southeastern California, south into Mexico.)
         18. Longitudinal series of large dorsal scales on posterior half of back separated or scattered by vertebral series of smaller scales (Fig. 66).
            19. No elongate tubercules or tufts of projecting spinose scales present on dorsolateral

7. *Crotaphytus wislizenii* and *C. silus* appear to be but poorly differentiated from each other and some confusion in their identification may be expected.

line of neck (Fig. 69); large dorsal scales rather weakly keeled; caudal scales less spinose or not spinose. Pigmy boulder uta................*Uta levis* Stejneger. (Great Basin of the West.)

19. Elongate tubercules or tufts of projecting spinose scales usually present on dorsolateral line of neck (Fig. 68); large dorsal scales strongly keeled; caudal scales more spinose.

  20. Largest dorsal scales in two or four rows, which are in rather definite longitudinal series for most of their length,[8] as evidenced by the longitudinal lines made by the various keels of these scales. Sonoran uta. *Uta ornata symmetrica* Baird. (Extreme western Texas, west through Arizona into southeastern California, south into Mexico.)

  20. Largest dorsal scales very irregularly placed, not in two or four definite longitudinal rows. Texas uta............*Uta ornata ornata* Baird and Girard. (Texas.)

17. Dorsal scales granular, sometimes with those on top of back enlarged but rather smoothly graded into lateral series without abrupt contrast.

  18. No dorsolateral skin fold, and lower lateral skin fold either present or absent on each side; a small blue-black (or black) ventrolateral spot often present a short distance back of insertion of forearm; scales of back usually less granular. Common uta, sand uta, rock lizard............................*Uta stansburiana* Baird and Girard. (Southwestern United States, from Oregon and Idaho, southeast through western Colorado and northern New Mexico into western Texas, south into Mexico.)

  18. A dorsolateral skin fold, and usually a lower lateral skin fold, present on each side; no small blue-black (or black) ventrolateral spot present back of insertion of forearm; scales of back more granular. Small-scaled uta....*Uta microscutata* Van Denburgh. (Southern California, south into Lower California, Mexico.)

13. Back and sides entirely covered with flat, strongly keeled, overlapping scales, which have conspicuous, posteriorly projecting points (Fig. 7). These keels and points form more or less parallel lines on the back and

8. Flat, small scales or granules cover the vertebral line and separate these enlarged longitudinal rows of scales into two series, two rows on each side. Further research may show the distinction between the two subspecies of *Uta ornata* to be untenable, since confusing variation exists.

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usually also on the sides and tail; dorsal and lateral scales graded, not of contrasting sizes (Fig. 7). Spiny lizards and scaly lizards (Genus *Sceloporus*).[9]

14. Keels of lateral scale rows parallel with those of median dorsal rows (or nearly so). Orange-sided spiny lizard .... *Sceloporus scalaris* Wiegmann.
    (Mountains of southern Arizona, south into Mexico.)

14. Keels of lateral scale rows oblique, not parallel with those of median dorsal rows.
    15. With (1) a blotch *or* (2) a collar of intense black *in front of* shoulder (at least in adults); the blotch or collar not similar to other markings on back. Consider second alternative carefully.
        16. A broad, black collar present in front of the shoulders, the lateral elements approaching or uniting along the middorsal line. A collar is described as being bar-like with nearly parallel edges.
            17. More than 51 scales from occiput to base of tail (opposite rear margin of hind leg). Ornate spiny lizard .... *Sceloporus ornatus* Baird.
                (Lower Rio Grande Valley of Texas, south into Mexico.)
            17. Less than 51 scales from occiput to base of tail.
                18. Less than 38 scales from occiput to base of tail. Mexican scaly lizard.
                    Sceloporus torquatus poinsettii Baird and Girard.[10]
                    (Texas and New Mexico, south into Mexico.)
                18. More than 38 scales from occiput to base of tail. Sonoran scaly lizard.
                    (Southeastern Arizona, south into Mexico.) *Sceloporus jarrovii* Cope.
        16. A black blotch in front of each shoulder, this confined to the lateral region or rapidly narrowed dorsally. A blotch is described as being irregular, not with parallel edges in most cases.
            17. External parietal and frontoparietal plates in contact with large supraoculars, not separated from supraoculars by a series of small scales (Fig. 61).
                18. Upper chest light, not entirely covered by gray bars or suffused with blue-black of rather uniform constituency. Desert scaly lizard.
                    Sceloporus clarkii clarkii Baird and Girard.[11]

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9. The distinctions between these forms are often difficult, especially in the young. The best results in identification may be obtained by the use of adult males.

10. My conception of this form includes *Sceloporus torquatus cyanogenys* Cope.

11. *Sceloporus clarkii* Baird and Girard, Proc. Acad. Nat. Sci. Philadelphia, Vol. 6, 1852, p. 127 (Sonora) and *S. magister* Hallowell, *Ibid.*, Vol. 7, 1854, p. 93 (Fort Yuma) show no constantcy in their described characters when examined in large numbers. the oldest males tending to have better developed ear denticulations than the rest of the population. Like other reptile species of the West, the ground color of the back is darker at higher altitudes and lighter (or more brownish) about the desert floor. Cope wrote in 1900, "the forms do not seem to me to be worthy of distinction as subspecies." Linsdale (1932) seems to have very appropriately recognized several subspecies of "*magister*" from Lower California and to the same complex another form from western Mexico may be added. All of these now become subspecies of *clarkii*. The subspecies of *clarkii* are therefore as follows: *boulengeri, clarkii, rufidorsum* and *zosteromus*.

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(Great Basin of the West, from southern Nevada east to southwestern Colorado, thence south through New Mexico, Arizona, and southern California, to northern Mexico.)

18. Upper chest darker, with conspicuous gray bars *or* suffused with blue-black. Dusky scaly lizard ....*Sceloporus orcutti* Stejneger.
(Coastal mountains of southern California, south into Lower California, Mexico.)

17. External parietal and frontoparietal plates separated from large supraoculars by a series of small scales called supraocular granules (Fig. 11).

18. Sixty-nine or more than 69 scales from occiput to base of tail, opposite rear side of hind leg; throat often distinctively variegated with black and white. Small-scaled spiny lizard ....*Sceloporus couchii* Baird.
(Southern Texas, south into Mexico.)

18. Less than 69 scales from occiput to base of tail; throat often with blue markings.

19. More than 50 scales from occiput to base of tail.

20. Dorsolateral stripes distinct; a regular row of dark brown spots present on each side of vertebral line; center of lateral belly patches bright pink. Texan rose-bellied spiny lizard....*Sceloporus variabilis marmoratus* (Hallowell).
(Central Texas, south into Mexico.)

20 Dorsolateral stripes absent; dorsal dark markings irregular or absent; center of lateral belly patches bright blue.

21. Lateral belly patches of males strongly emarginated with black or indigo blue, at least posteriorly; body often grayish or olivaceous above. Pecos spiny lizard........................*Sceloporus merriami* Stejneger.
(Valley of the Rio Grande, western Texas.)

21. Lateral belly patches of males weakly emarginated posteriorly, or not bordered at all by dark markings; body with much brown above. South Texas spiny lizard..................*Sceloporus disparilis* Stejneger.
(Valley of the Lower Rio Grande, in Texas and Mexico.)

A KEY TO THE LIZARDS OF THE UNITED STATES AND CANADA—CONTINUED

19. Fifty or less than 50 scales from occiput to base of tail (all specimens tracing to this point should be referred through the part of alternative No. 15 that follows *immediately below* and then traced down from No. 16 in the usual manner).

15. Usually no black blotch or collar present in front of shoulder; black blotch, *if* present, either posthumeral, diffused into the general ground color, or merely a poorly delineated lateral extension from the colored gular suffusion of adult males.

16. Size larger, body length (snout to anus) more than 90 mm.

17. Subcaudal scales smooth for at least one or two centimeters (half an inch) back of transverse anal slit. Dusky scaly lizard........................*Sceloporus orcutti* Stejneger.
(Coastal mountains of southern California, south into Lower California, Mexico.)

17. Subcaudal scales weakly keeled, even in immediate postanal region. Mexican tree lizard.
Sceloporus spinosus Wiegmann.
(Southeastern New Mexico to south-central Oklahoma, south through Texas into Mexico.)

16. Size smaller, body length (snout to anus) less than 90 mm.

17. Thirty-seven or less than 37 scales from occiput to base of tail (opposite posterior margin of hind leg).

18. Large external parietals and the two separated frontoparietal plates in contact with the enlarged supraoculars on each side, not isolated by a series of small scales called supraocular granules (Fig. 61). Dusky scaly lizard.....*Sceloporus orcutti* Stejneger.
(Coastal mountains of southern California, south into Lower California, Mexico.)

18. Large external parietals and the two separated frontoparietal plates not in contact with the enlarged supraoculars, isolated by a series of supraocular granules (Fig. 11).

19. Usually less than 35 scales from occiput to base of tail; throat light, without blue spots. Mexican tree lizard..................*Sceloporus spinosus* Wiegmann.[12]
(Southeastern New Mexico to south-central Oklahoma, south through Texas into Mexico.)

12. The recently described *S. olivaceus* Smith (Trans. Kansas Acad. Sci., vol. 37, 1934, p. 277) will identify here. The slight distinctions drawn between the single type specimen of *olivaceus* and several examples of *spinosus* all appear to be descriptions of features that show individual variation in regard to detail or proportion. The fact that the type of *olivaceus* was obtained in "an area where *spinosus* is very abundant" supports the view that it is merely a representative of that form with a special mendelian combination of characters rather than any normal specific or subspecific descendant of the *spinosus* population. The characters of "*olivaceus*" seem too close to those of *spinosus* to exclude it from the *spinosus* complex and under the application of Jordan's Law, closely allied populations usually occur in nature in adjacent ranges rather than in a common habitat, exclusive of points of intergradation.

A KEY TO THE LIZARDS OF THE UNITED STATES AND CANADA—CONTINUED

19. Rarely less than 33 scales from occiput to base of tail; throat with one or two conspicuous blue spots in adult males (these spots are lighter, highly diffused, or even absent in the females and young).
  20. Adult males with ventrolateral blue patches separated by a whitish midventral area of considerable width; blue on under surface of body not confluent with blue of throat; females less dusky below. North Sierra spiny lizard.
  Sceloporus graciosus gracilis Baird and Girard.
  (Western Washington, south to central California.)
  20. Adult males with ventrolateral blue patches united across midventral line or separated by a narrow whitish interval; blue or black of belly confluent with that of throat; under surface of tail and thighs often colored. South Sierra spiny lizard..................*Sceloporus graciosus vandenburgianus* Cope.
  (Mountains of southern California, south into Lower California, Mexico).

17. More than 37 scales from occiput to base of tail.
18. Forty-eight or more than 48 scales from occiput to base of tail.
19. Sixty-nine or more than 69 scales from occiput to base of tail; throat often distinctively variegated with black and white. Small-scaled spiny lizard.
(Southern Texas, south into Mexico.) *Sceloporus couchii* Baird.
19. Less than 69 scales from occiput to base of tail; throat often with blue markings.
  20. More than 59 scales from occiput to base of tail.
    21. Belly patches always blue when distinct; dorsolateral stripe absent or clouded. South Texas spiny lizard....*Sceloporus disparilis* Stejneger.
    (Valley of the lower Rio Grande, in Texas and Mexico.)
    21. Belly patches with dark blue or black edges and pink centers when distinct; dorsolateral stripe often distinct. Texan rose-bellied spiny lizard.
    Sceloporus variabilis marmoratus (Hallowell).
    (Central Texas, south into Mexico.)
  20. Fifty-nine or less than 59 scales from occiput to base of tail.
    21. Scales on inner and upper posterior half of thigh smaller, often granular and usually smooth, *but* sometimes with a central patch of small, acuminate (or posteriorly pointed), keeled platelets (Fig. 63). Sides of throat never with two well-defined blue spots; sides of body sometimes reddish orange; range west or south of Great Plains area.

A KEY TO THE LIZARDS OF THE UNITED STATES AND CANADA—CONTINUED

22. Dorsal scales larger, usually less than 52 between occiput and base of tail; usually with very distinct longitudinal light stripes on body. Sagebrush lizard..*Sceloporus graciosus graciosus* Baird and Girard. (Great Basin of the West, from eastern Washington to Montana, south to northern Arizona and New Mexico.)

22. Dorsal scales smaller, usually more than 52 between occiput and base of tail; usually (but not always) with indistinct longitudinal light stripes on body or none at all.

  23. Centers of ventrolateral belly patches of males normally pink. Texan rose-bellied spiny lizard.
  Sceloporus variabilis marmoratus (Hallowell).
  (Central Texas, south into Mexico.)

  23. Centers of ventrolateral belly patches of males normally bright blue.

    24. Adult males with ventrolateral blue patches separated by a whitish midventral area of considerable width; blue on under surface of body not confluent with blue of throat; females less dusky below. North Sierra spiny lizard.
    Sceloporus graciosus gracilis Baird and Girard.
    (Western Washington, south to Central California.)

    24. Adult males with ventrolateral blue patches united across midventral line or separated by a narrow whitish interval; blue or black of belly confluent with that of throat; under surface of tail and thighs often colored. South Sierra spiny lizard.......*Sceloporus graciosus vandenburgianus* Cope.
    (Mountains of southern California, south into Lower California, Mexico.)

21. Scales on inner and upper posterior half of thigh larger, acuminate (or posteriorly pointed) and keeled (Fig. 62); sides of throat with *or* without well defined blue spots (all specimens tracing to this point should be referred through the part of alternative No. 18 that follows *immediately below* and then traced down from No. 19 in the usual manner).

A KEY TO THE LIZARDS OF THE UNITED STATES AND CANADA—CONTINUED

18. Less than 48 scales from occiput to base of tail.
    19. Back distinctly striped, usually with spots or nonundulating markings.
        20. A narrow, light vertebral stripe; male with diffused gular markings, or none at all. Sagebrush lizard. .*Sceloporus graciosus graciosus* Baird and Girard. (Great Basin of the West, from eastern Washington to Montana, south to northern Arizona and New Mexico.)
        20. No light vertebral stripe; male usually with two lateral gular spots.
            21. Distance between base of inner toe of hind foot and tip of fourth toe not usually decidedly greater than distance between tip of snout and tympanum; ground color of back often brown or olivaceous; light blue not usually predominant in dorsal coloration. Prairie spiny lizard. *Sceloporus undulatus consobrinus* Baird and Girard. (Central Texas north to central South Dakota, thence west to eastern Wyoming, south through central Colorado to northern New Mexico, west Arizona, and south into Mexico.)
            21. Distance between base of inner toe of hind foot and tip of fourth toe often decidedly greater than distance between tip of snout and tympanum; ground color of back blue or olive gray in most cases. Florida fence lizard..................*Sceloporus undulatus woodi* Stejneger. (Peninsular Florida.)
    19. Back not distinctly striped, usually with wavy dark brown crossbars.
        20. Eastern and Great Plains forms: Atlantic and Gulf coasts and the Mississippi Valley, north into Canada; sometimes less than 20 subdigital lamellae under longest toe of hind foot; structural features highly variable, often practically identical with western forms.
            21. Ground color of back often brown, olivaceous, or blackish, with light blue normally not predominant in the dorsal coloration; undulating (or wavy) dark dorsal crossbars usually (but not always) distinct, often heavy; distance between base of inner toe of hind foot and tip of fourth toe *often* not decidedly greater than distance between tip of snout and tympanum. Eastern spiny lizard, common fence lizard, or pine lizard. *Sceloporus undulatus undulatus* (Latreille). (Eastern United States from New York west to Wisconsin, southwest to

A KEY TO THE LIZARDS OF THE UNITED STATES AND CANADA—CONTINUED

eastern Kansas and south through central Oklahoma and Texas into Mexico.)

21. Ground color of body blue gray or olive gray, rarely light brown; undulating dark dorsal crossbars usually reduced, not heavy, sometimes absent; distance between base of inner toe of hind foot and tip of fourth toe *often* decidedly greater than distance between tip of snout and tympanum.

 22. More than 33 scales from the occiput to the base of the tail. Florida fence lizard..............*Sceloporus undulatus woodi* Stejneger. (Peninsular Florida.)

 22. Thirty-three or less than 33 scales from the occiput to the base of the tail. Pensacolan fence lizard.
 Sceloporus undulatus floridanus Baird.
 (Coastal plain of northwestern Florida.)

20. Western forms: Pacific Coast and Great Basin of the West; ***usually*** over 20 subdigital lamellae under longest toe of hind foot; structural features highly variable, often practically identical with eastern forms.

21. Dorsal scales larger, usually 42 or less than 42 between occiput and base of tail.

 22. Under surface of head (labial region, chin and throat) crossed by irregular diagonal dark lines, which radiate from the gular region. Channel Island spiny lizard.
 Sceloporus undulatus becki Van Denburgh.
 (Santa Barbara or Channel Islands off coast of Santa Barbara county, California.)

 22. Under surface of head not usually crossed by irregular diagonal dark lines, which radiate from irregular black spots or flecks.

  23. Blue of throat in males often in paired lateral patches (blue widest laterally or separated by median white strip), which may merge centrally in older specimens; under parts very light in color or speckled with darker scales. A poorly differentiated subspecies. Northwestern spiny lizard.
  Sceloporus undulatus occidentalis Baird and Girard.

A KEY TO THE LIZARDS OF THE UNITED STATES AND CANADA—CONCLUDED

(Pacific coast of North America from British Columbia south through western Washington and Oregon into northern California.)

23. Blue of throat in males in a central patch, never divided; under parts often gray or black. A poorly differentiated subspecies. Southwestern spiny lizard.
Sceloporus undulatus bi-seriatus Hallowell.
(Southern Idaho, southwest through Nevada into California, and south into Lower California, Mexico; intergrades with *elongatus* in eastern Nevada and western Utah.)

21. Dorsal scales smaller, usually over 42 between occiput and base of tail.

22. Under surface of head (labial region, chin and throat) crossed by irregular diagonal dark lines, which radiate from the gular region. Channel Island spiny lizard.
Sceloporus undulatus becki Van Denburgh.
(Santa Barbara or Channel Islands off coast of Santa Barbara county, California.)

22. Under surface of head not usually crossed by irregular diagonal dark lines; throat white and blue, with or without irregular black spots or flecks.

23. Blue belly patches, when discernible, separated from the blue throat patches; belly patches separated from each other by a white band of considerable width. Desert spiny lizard.
Sceloporus undulatus elongatus Stejneger.
(Great Basin of the West, from western Colorado and northwestern New Mexico, west through northern Arizona and southern Utah; intergrades with *biseriatus* in eastern Nevada and western Utah.)

23. Blue belly patches, when discernible, confluent with the throat patch; belly patches in contact; abdominal color usually deep blue throughout, especially in adult males. Yosemite spiny lizard..................*Sceloporus undulatus taylori* Camp.
(Upper basins of the Tuolumne and Merced rivers, above 7,000 feet altitude, in Yosemite National Park.)

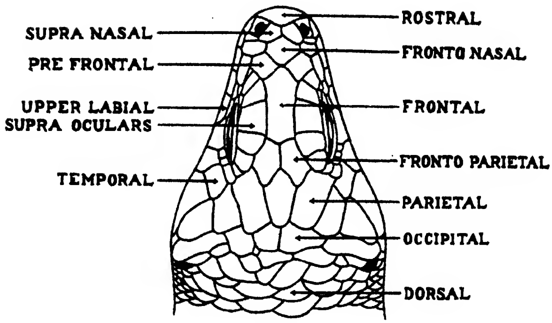

FIG. 1

FIG. 1. *Eumeces obsoletus.* Top of head.

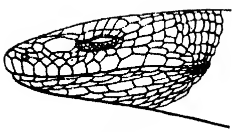

FIG. 2

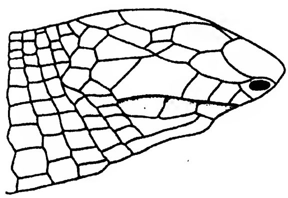

FIG. 3

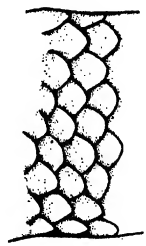

FIG. 4

FIG. 2. *Ophisaurus ventralis* (U.S.N.M. 48358). Mount Pleasant, Charleston county, South Carolina. Side view of head.

FIG. 3. *Rhineura floridana* (after Cope, 1900). Side view of head.

FIG. 4. *Anniella pulchra* (after Cope, 1900). Section of lateral scales.

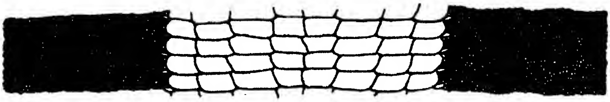

FIG. 5

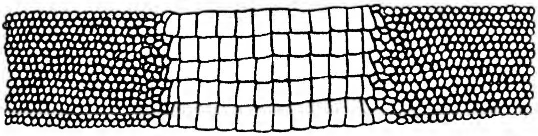

FIG. 6

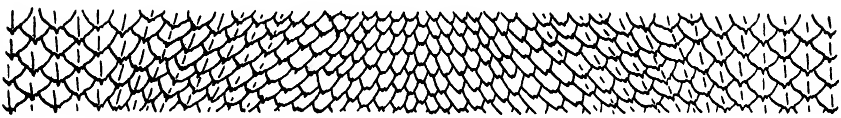

FIG. 7

FIG. 5. *Cnemidophorus sexlineatus sexlineatus* (U.S.N.M. 85483). Ooltewah, Hamilton county, Tennessee. Strip around center of body, broken at mid-dorsal line.

FIG. 6. *Xantusia vigilis* (U.S.N.M. 69834). Antelope Valley, Los Angeles county, California. Strip around center of body, broken at middorsal line.

FIG. 7. *Sceloporus undulatus undulatus* (U.S.N.M. 85488). Rogersville, Webster county, Missouri. Strip around center of body, broken at middorsal line.

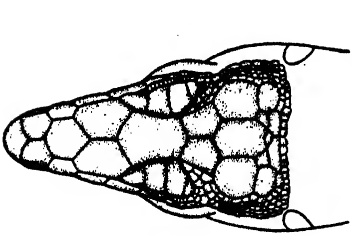

FIG. 8

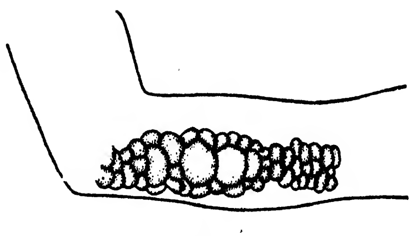

FIG. 9

FIG. 8. *Cnemidophorus tessellatus tessellatus* (after Cope, 1900). Top of head.

FIG. 9. *Cnemidophorus sexlineatus perplexus* (after Cope, 1900). Posterior side of forearm.

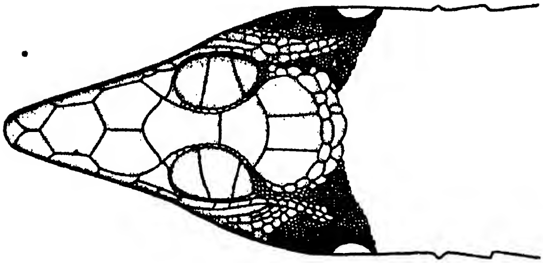

FIG. 10

FIG. 10. *Cnemidophorus hyperythrus hyperythrus* (after Cope, 1900). Top of head.

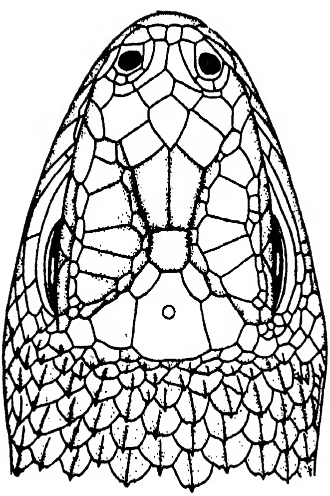

FIG. 11

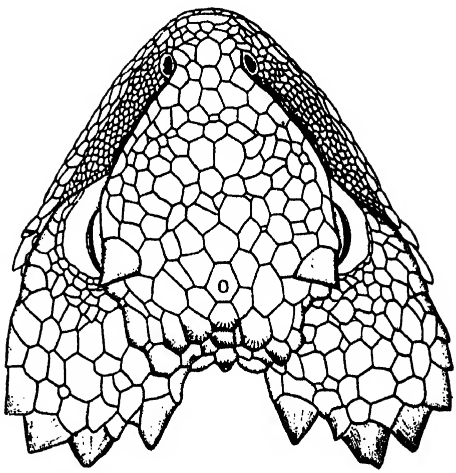

FIG. 12

FIG. 11. *Sceloporus undulatus floridanus* (after Cope, 1900). Top of head.
FIG. 12. *Phrynosoma douglassii hernandesi* (after Cope, 1900). Top of head.

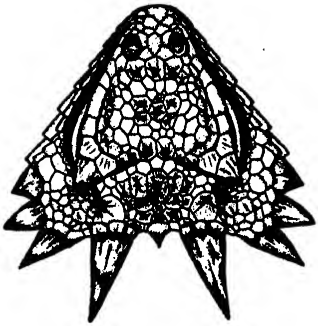

FIG. 13

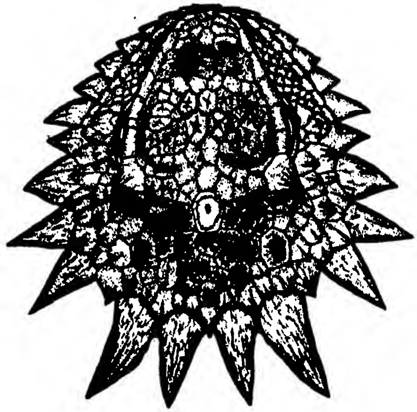

FIG. 14

FIG. 13. *Phrynosoma cornutum* (after Cope, 1900). Top of head.
FIG. 14. *Phrynosoma solare* (after Cope, 1900). Top of head.

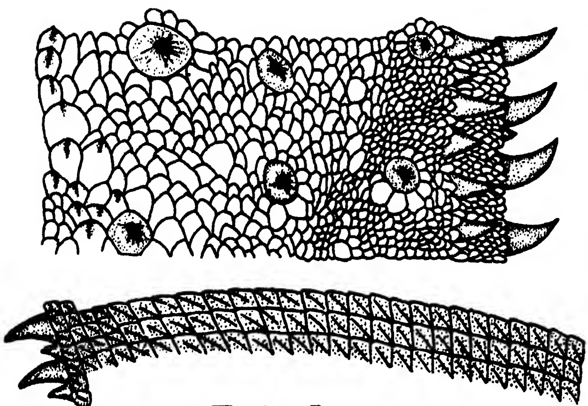

FIG. 15

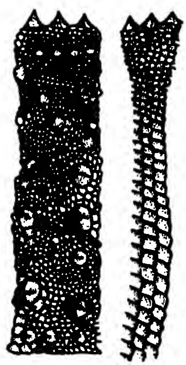

FIG. 16

FIG. 15. *Phrynosoma cornutum* (after Cope, 1900). Wide strip on side of body from middorsal line to lateral fringes, and narrow strip from lower lateral fringe to midventral line.

FIG. 16. *Phrynosoma platyrhinos* (after Cope, 1900). Wide strip on side of body from middorsal line to lateral fringes, and narrow strip from lower lateral fringe to midventral line.

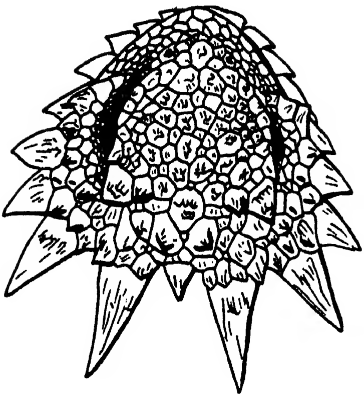

FIG. 17

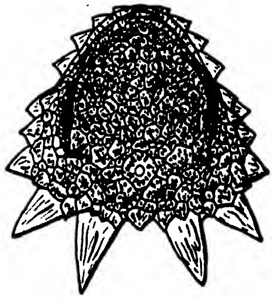

FIG. 18

FIG. 17. *Phrynosoma coronatum blainvillii* (U.S.N.M. 64285). Twin Oaks, California. Top of head.

FIG. 18. *Phrynosoma coronatum frontale* (U.S.N.M. 59842). Cuyama Valley, California. Top of head.

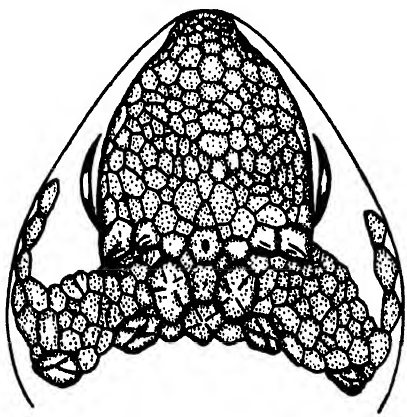

FIG. 19

FIG. 19. *Phrynosoma douglassii douglassii* (after Cope, 1900). Top of head.

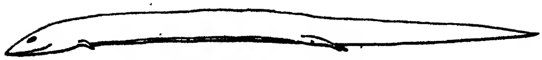

FIG. 20

FIG. 21

FIG. 20. *Neoseps reynoldsi* (U.S.N.M. 48600). Fruitland Park, Florida. Side view of body, showing vestigial limbs.

FIG. 21. *Leiolopisma unicolor* (U.S.N.M. 11998). Georgiana, Florida. Side view of body, showing weak but fully developed limbs.

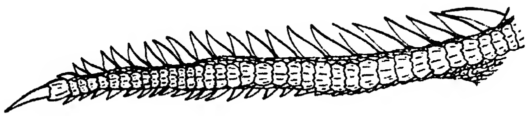

FIG. 22

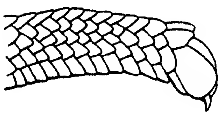

FIG. 23

FIG. 22. *Callisaurus notatus* (U.S.N.M. 81187). 10 mi. N. Palm Springs, Riverside county, California. Longest digit of hind foot, showing lateral fringes.

FIG. 23. *Coleonyx brevis* (U.S.N.M. 13627). Helotes, Texas. Tip of longest digit of hind foot.

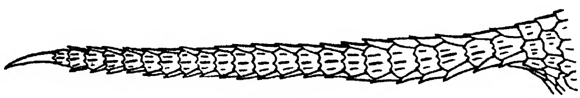

FIG. 24

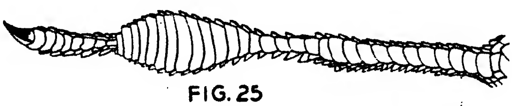

FIG. 25

FIG. 24. *Sceloporus undulatus woodi* (U.S.N.M. 48720). Auburndale, Florida. Longest digit of hind foot.

FIG. 25. *Anolis stejnegeri* (U.S.N.M. 85181). Key West, Florida. Longest digit of hind foot.

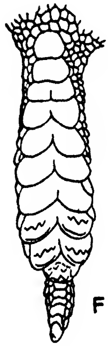

FIG. 26

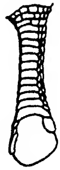

FIG. 28

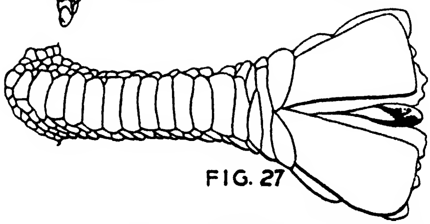

FIG. 27

FIG. 26. *Hemidactylus turcicus* (U.S.N.M. 61255). Key West, Florida. Longest digit of hind foot.

FIG. 27. *Phyllodactylus tuberculosis* (U.S.N.M. 64455). Miraflores, Lower California, Mexico. Longest digit of hind foot.

FIG. 28. *Sphaerodactylus cinereus* (U.S.N.M. 64934). Key West, Florida. Longest digit of hind foot.

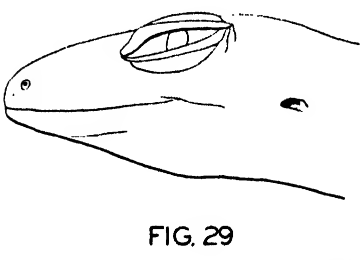

FIG. 29

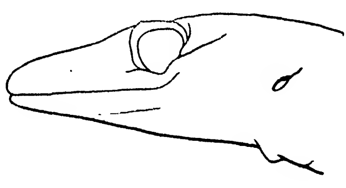

FIG. 30

FIG. 29. *Phyllodactylus tuberculosis* (U.S.N.M. 64455). Miraflores, Lower California, Mexico. Side of head.

FIG. 30. *Coleonyx brevis* (U.S.N.M. 13627). Helotes, Texas. Side of head.

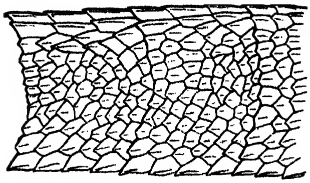

FIG. 31

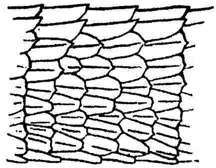

FIG. 32

FIG. 31. *Anolis stejnegeri* (U.S.N.M. 85183). Key West, Florida. Side view of tail. Note contrast in scale sizes.

FIG. 32. *Anolis carolinensis* (U.S.N.M. 4177). St. Augustine, Florida. Side view of tail. Note large size of all scales.

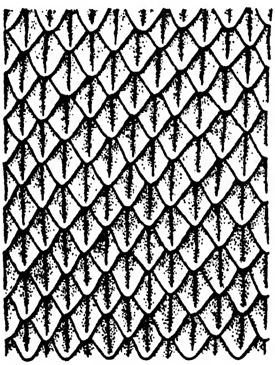

FIG. 33

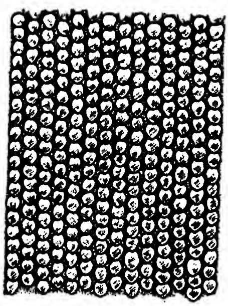

FIG. 34

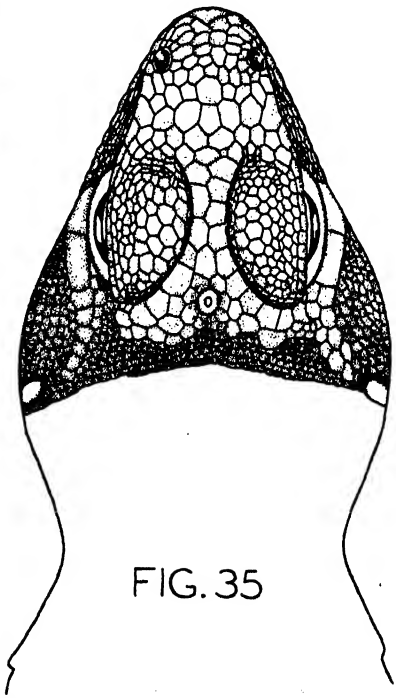

FIG. 35

FIG. 33. *Sphaerodactylus notatus* (after Barbour, 1921). Patch of dorsal scales.

FIG. 34. *Sphaerodactylus cinereus* (after Barbour, 1921). Patch of dorsal scales.

FIG. 35. *Crotaphytus collaris* (after Cope, 1900). Top of head.

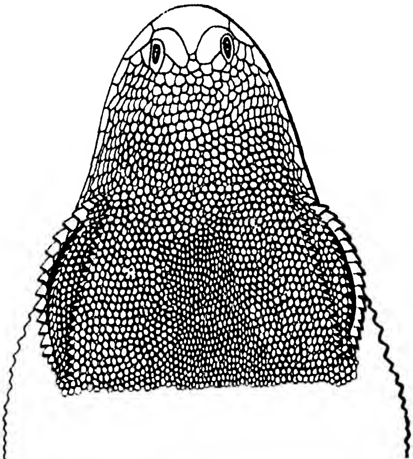

FIG. 36

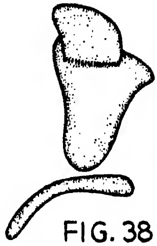

FIG. 38

FIG. 37

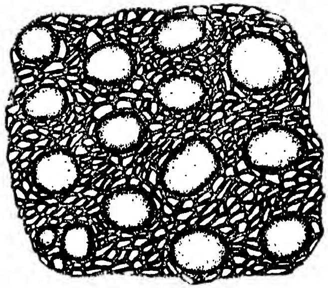

FIG 39

FIG. 36. *Coleonyx brevis* (U.S.N.M. 13627). Helotes, Texas. Top of head.

FIG. 37. *Coleonyx brevis* (after Smith, 1933). Cloacal bones.

FIG. 38. *Coleonyx variegatus* (after Smith, 1933). Cloacal bones.

FIG. 39. *Heloderma suspectum* (laboratory specimen, Southwestern College). Patch of dorsal scales.

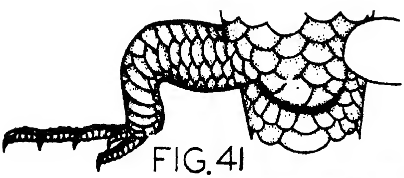

FIG. 41

FIG. 40

FIG. 40. *Crotaphytus collaris* (after Cope, 1900). Ventral view of thigh, showing femoral pores.

FIG. 41. *Eumeces egregius* (after Cope, 1900). Ventral view of thigh.

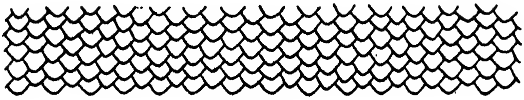

FIG. 42

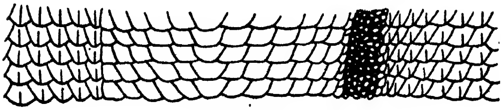

FIG. 43

FIG. 42. *Eumeces tetragrammus* (U.S.N.M. 3124). Matamoras, Mexico. Strip around center of body, broken at middorsal line.

FIG. 43. *Gerrhonotus multi-carinatus webbii* (U.S. N.M. 37687). Strip around center of body, broken at middorsal line. Lateral fold closed on one side and open on the other.

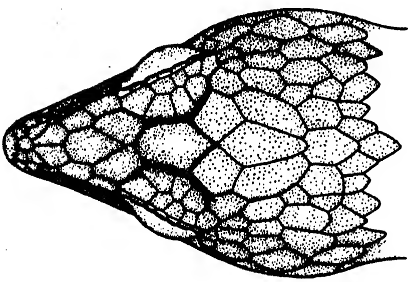

FIG. 44

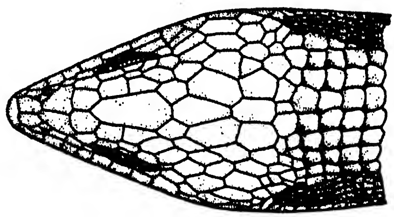

FIG. 45

FIG. 44. *Gerrhonotus infernalis* (after Cope, 1900). Top of head.
FIG. 45. *Barissia levicollis* (after Cope, 1900). Top of head.

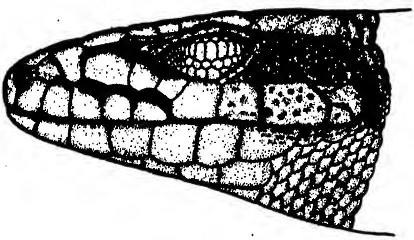

FIG. 46

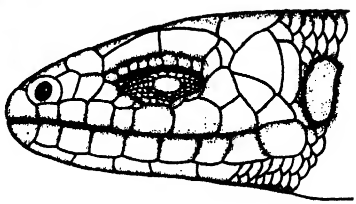

FIG. 47

FIG. 46. *Eumeces* (after Ortenburger, 1930). Side view of head showing scaled lower eyelid.

FIG. 47. *Leiolopisma unicolor* (after Ortenburger, 1930). Side view of head showing transparent disc in center of lower eyelid.

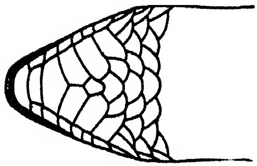

FIG. 48

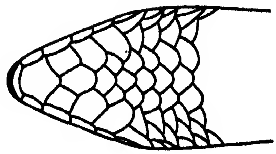

FIG. 49

FIG. 48. *Eumeces tetragrammus* (after Cope, 1900). Ventral view of head.

FIG. 49. *Eumeces anthracinus* (after Cope, 1900). Ventral view of head.

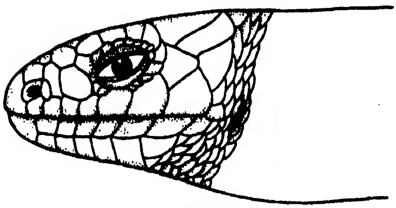

FIG. 50

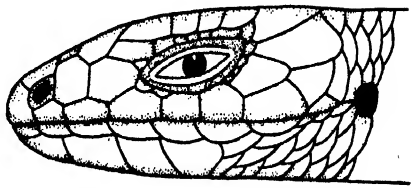

FIG. 51

FIG. 50. *Eumeces obsoletus* (after Cope, 1900). Side view of head.

FIG. 51. *Eumeces anthracinus* (after Cope, 1900). Side view of head.

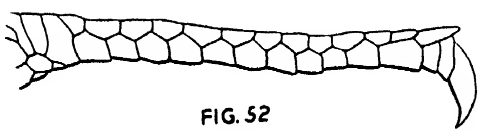

FIG. 52

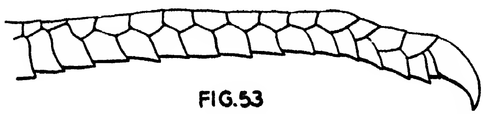

FIG. 53

FIG. 52. *Eumeces fasciatus* (U.S.N.M. 44722). Marble Cave, Missouri. Longest digit of hind foot.

FIG. 53. *Eumeces skiltonianus* (U.S.N.M. 36354). Beaver county, Utah. Longest digit of hind foot.

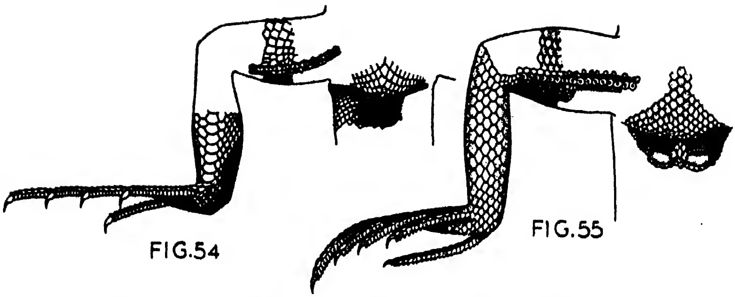

FIG.54

FIG.55

FIG. 54. *Holbrookia maculata lacerata* (after Cope, 1900). Ventral view of thigh and anal region, male.

FIG. 55. *Holbrookia maculata maculata* (after Cope, 1900). Ventral view of thigh and anal region, female.

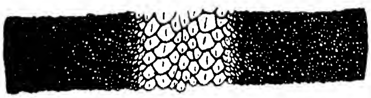

FIG.56

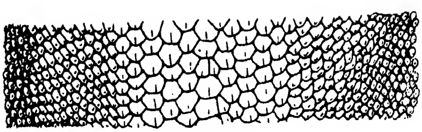

FIG.57

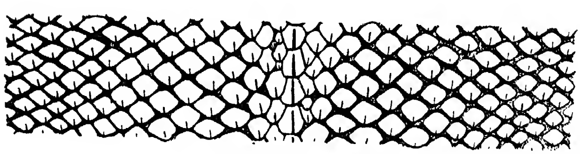

FIG. 58

FIG. 56. *Uta levis* (U.S.N.M. 8554). Amarillo, Mexico. Strip across middle of back.

FIG. 57. *Uta stansburiana* (U.S.N.M. 4957). Pecos River, Texas. Strip across middle of back.

FIG. 58. *Dipsosaurus dorsalis* (U.S.N.M. 45032). Yuma, Arizona. Strip across back and sides.

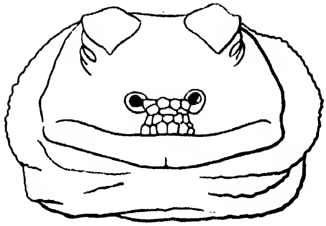

FIG. 59

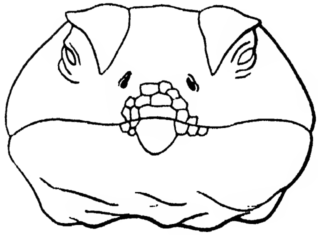

FIG. 60

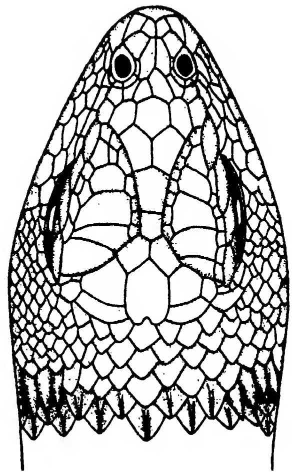

FIG. 61

FIG. 59. *Sauromalus obesus* (U.S.N.M. 16503). Colorado Desert, San Diego county, California. End view of snout to show divided rostral plate.

FIG. 60. *Crotaphytus reticulatus* (U.S.N.M. 2731). Laredo, Texas. End view of snout to show undivided rostral plate.

FIG. 61. *Sceloporus orcuttii* (after Cope, 1900). Top of head.

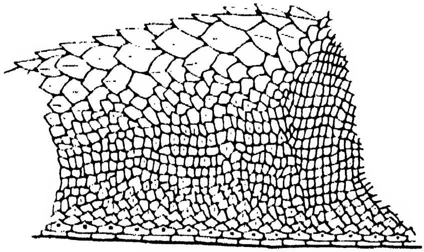

FIG. 62

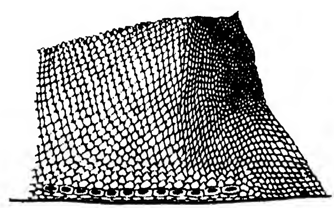

FIG. 63

FIG. 62. *Sceloporus undulatus undulatus* (U.S.N.M. 85488). Rogersville, Missouri. Posterior side of femur showing scales.

FIG. 63. *Sceloporus variabilis* (U.S.N.M. 15655). San Diego, Texas. Posterior side of femur showing scales.

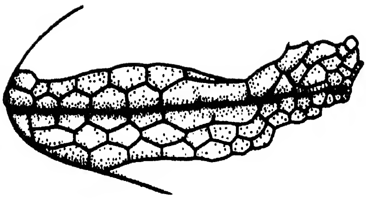

FIG.64

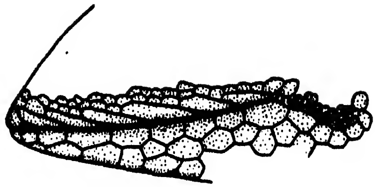

FIG.65

FIG. 64. *Uta graciosa* (U.S.N.M. 15962). Yuma, Arizona. Labial scales.
FIG. 65. *Holbrookia maculata maculata* (after Schmidt, 1922). Labial scales.

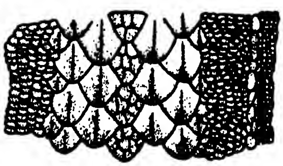

FIG. 66

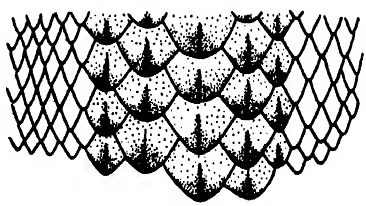

FIG. 67

FIG. 66. *Uta ornata symmetrica* (U.S.N.M. 15730). Phoenix, Arizona. Strip ross vertebral line.
FIG. 67. *Uta graciosa* (after Cope, 1900). Strip across vertebral line.

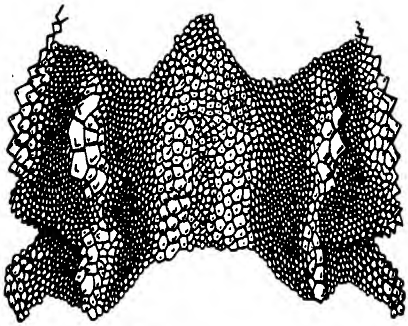

FIG.68

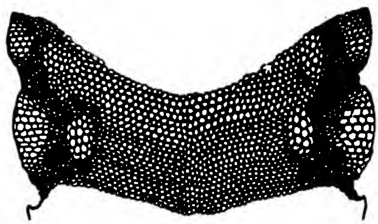

FIG.69

FIG. 68. *Uta ornata symmetrica* (U.S.N.M. 15731). Tuscon, Arizona. Ventral view of neck.

FIG. 69. *Uta levis* (U.S.N.M. 8554). Amarillo, Mexico. Ventral view of neck.

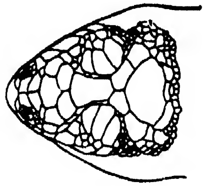

FIG.70

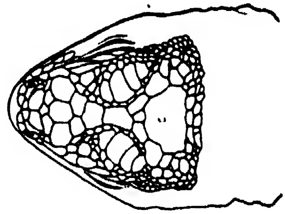

FIG 71

FIG. 70. *Uta microscutata* (U.S.N.M. 37615). Santana, Lower California, Mexico. Top of head.

FIG. 71. *Uta stansburiana* (U.S.N.M. 4957). Pecos, River, Texas. Top of head.

CHECK LIST OF THE LIZARDS OF THE UNITED STATES AND CANADA

The present check list is merely a presentation of the scientific names of the 99 lizards of the United States and Canada, arranged more or less phylogenetically according to families and genera. The species and subspecies are listed alphabetically. The common name of each form is placed in the first column to the right and this is followed by the citation of one of the best and most generally available descriptions. The most valuable reference works are by Van Denburgh (1922) and Cope (1900), and the full reference to these contributions and others may be found in the accompanying bibliography. When a description is illustrated, this has been denoted by an asterisk (*) after the manner of current issues of Biological Abstracts. A statement of range for each will be found in the key above. The place of original description and the type locality of a given lizard may be found in most cases by simple reference to the literature cited or by consulting Stejneger and Barbour's recent Check List of North American Amphibians and Reptiles (1933).

A. Family Gekkonidae

Classification	Common name	Description
1. *Hemidactylus turcicus* (L.)	European gecko	Boulenger 1885 (1), 126
2. *Phyllodactylus tuberculosus* Wieg.	Warty gecko	Cope 1900, 458*
3. *Sphaerodactylus cinereus* Wagler	Antillean gecko	Barbour 1921, 233*
4. *S. notatus* Baird	Reef gecko	Barbour 1921, 256*
5. *Coleonyx brevis* Stej.	Texan desert gecko	Smith 1932, 301*
6. *C. variegatus* (Baird)	Sonoran desert gecko	Van Denb. 1922, 58*

B. Family Iguanidae

Classification	Common name	Description
7. *Anolis carolinensis* Voigt	American "chameleon"	Ditmars 1930, 102*
8. *A. stejnegeri* Barbour	Ring-tailed anolis	Barbour 1931, 88
9. *Ctenosaura acanthura* Shaw	Mexican spiny-tailed iguana	Bailey 1928, 9*
10. *Dipso-saurus dorsalis dorsalis* (B. and G.)	Short-headed sand iguana	Van Denb. 1922, 75*
11. *Crotaphytus collaris* (Say)	Collared lizard, mountain boomer	Ditmars 1930, 113*
12. *C. reticulatus* Baird	Reticulated lizard	Cope 1900, 254*
13. *C. silus* Stej.	Short-nosed leopard lizard	Van Denb. 1922, 128*

Classification	Common name	Description
14. *C. wislizenii* B. and G.	Common leopard lizard	Van Denb. 1922, 116*
15. *Sauromalus obesus* (Baird)	Chuckwalla	Cope 1900, 266*
16. *Callisaurus draconoides ventralis* Hallow.	Desert gridiron-tailed lizard	Cope 199, 269* Burt 1933, 230
17. *C. notatus* (Baird)	Ocellated sand lizard	Van Denb. 1922, 132*
18. *Holbrookia maculata lacerata* Cope	Small zebra-tailed sand lizard	Cope 1900, 292*
19. *H. m. maculata* Gir.	Common spotted sand lizard	Boulenger 1885 (2), 209
20. *H. m. propinqua* B. and G.	East Texas sand lizard	Cope 1900, 289*
21. *H. texana* (Troschel)	Large zebra-tailed sand lizard	Cope 1900, 286*
22. *Uta graciosa* Hallow.	Long-tailed uta	Van Denb. 1922, 212*
23. *U. levis* Stej.	Pigmy boulder uta	Woodbury 1931, 33*
24. *U. mearnsi* Stej.	Giant boulder uta	Van Denb. 1922, 191*
25. *U. microscutata* Van Denb.	Small-scaled uta	Van Denb. 1922, 219
26. *U. ornata ornata* B. and G.	Texas uta	Cope 1900, 315*
27. *U. o. symmetrica* Baird	Sonoran uta	Van Denb. 1922, 202*
28. *U. stansburiana* B. and G.	Common uta, sand uta, rock lizard	Cope 1900, 306*
29. *Sceloporus couchii* Baird	Small-scaled spiny lizard	Cope 1900, 395*
30. *S. disparilis* Stej.	South Texas spiny lizard	Stejneger 1916, 227
31. *S. graciosus gracilis* B. and G.	North Sierra spiny lizard	Van Denb. 1922, 280
32. *S. g. graciosus* B. and G.	Sagebrush lizard	Van Denb. 1922, 273*
33. *S. g. vandenburgianus* Cope	South Sierra spiny lizard	Cope 1900, 390*
34. *S. jarrovii* Cope	Sonoran scaly lizard	Van Denb. 1922, 321*
35. *S. clarkii clarkii* B. and G.	Desert scaly lizard	Van Denb. 1922, 329*
36. *S. merriami* Stej.	Pecos spiny lizard	Stejneger 1904, 17
37. *S. orcutti* Stej.	Dusky scaly lizard	Van Denb. 1922, 352*
38. *S. ornatus* Baird	Ornate spiny lizard	Cope 1900, 344*
39. *S. scalaris* Wieg.	Orange-sided spiny lizard	Van Denb. 1922, 268*
40. *S. spinosus* Wieg.	Mexican tree lizard	Boulenger 1885 (2), 226

Classification	Common name	Description
41. *S. torquatus poinsettii* B. and G.	Mexican scaly lizard	Cope 1900, 350*
42. *S. undulatus becki* Van Denb.	Channel Island spiny lizard	Van Denb. 1922, 318*
43. *S. u. bi-seriatus* Hallow.	Southwestern spiny lizard	Van Denb. 1922, 304*
44. *S. u. consobrinus* B. and G.	Prairie spiny lizard	Van Denb. 1922, 290*
45. *S. u. elongatus* Stej.	Desert spiny lizard	Van Denb. 1922, 295*
46. *S. u. floridanus* Baird	Pensacolan fence lizard	Burt 1936.
47. *S. u. occidentalis* B. and G.	Northwestern spiny lizard	Van Denb. 1922, 298*
48. *S. u. taylori* Camp	Yosemite spiny lizard	Van Denb. 1922, 315
49. *S. u. undulatus* (Latr.)	Eastern spiny lizard, common fence lizard, pine lizard	Cope 1900, 370*
50. *S. u. woodi* Stej.	Florida fence lizard	Stejneger 1918, 90
51. *S. variabilis marmoratus* (Hallow.)	Texan rose-bellied spiny lizard	Cope 1900, 398*
52. *Phrynosoma cornutum* (Harl.)	Texas "horned toad"	Van Denb. 1922, 409*
53. *P. coronatum blainvilli* Gray	Southern yellow-breasted "horned toad"	Van Denb. 1922, 388*
54. *P. c. frontale* Van Denb.	Northern yellow-breasted "horned toad"	Van Denb. 1922, 395*
55. *P. ditmarsi* Stej.	Stump-horned "horned toad"	Ditmars 1930, 154*
56. *P. douglassii douglassii* (Bell)	Pigmy "horned toad"	Cope 1900, 411*
57. *P. d. hernandesi* (Gir.)	Shorthorn "horned toad"	Van Denb. 1922, 382*
58. *P. m'callii* (Hallow.)	Flat-tailed "horned toad"	Van Denb. 1922, 428*
59. *P. modestum* Gir.	Round-tailed "horned toad"	Van Denb. 1922, 430*
60. *P. platyrhinos* Gir.	Desert "horned toad"	Van Denb. 1922, 421*
61. *P. solare* Gray	Regal "horned toad"	Van Denb. 1922, 406*

C. Family Xantusiidae

Classification	Common name	Description
62. *Xantusia arizonae* Klauber	Arizona night lizard	Klauber 1931, 3*
63. *X. henshawi* Stej.	Spotted night lizard	Van Denb. 1922, 484*
64. *X. riversiana* Cope	Island night lizard	Van Denb. 1922, 486*
65. *X. vigilis* Baird	Desert night lizard	Van Denb. 1922, 477*

	Classification	Common name	Description
	D. Family Lacertidae		
66.	*Lacerta melisellensis fiumana* Wern.	European wall lizard	Boulenger 1913, 167*
	E. Family Teiidae		
67.	*Cnemidophorus hyperythrus hyperythrus* Cope	Orange-throated race-runner	Burt 1931, 226
68.	*C. sexlineatus perplexus* B. and G.	Sonoran race-runner	Burt 1931, 122*
69.	*C. s. sackii* Wieg.	Spotted race-runner	Burt 1931, 97
70.	*C. s. sexlineatus* (L.)	Six-lined race-runner	Burt 1931, 76
71.	*C. tessellatus tessellatus* (Say)	Desert whiptail, tiger lizard	Burt 1931, 146
	F. Family Scincidae		
72.	*Leiolopisma unicolor* (Harl.)	Brown-backed skink	Cope 1900, 623*
73.	*Eumeces anthracinus* Baird	Black skink, brown banded skink	Cope 1900, 661*
74.	*E. brevilineatus* Cope	Short-lined skink	Cope 1900, 664*
75.	*E. callicephalus* Bocourt	Sonoran stone skink	Taylor 1929, 67
76.	*E. egregius* (Baird)	Fragile skink	Cope 1900, 655*
77.	*E. fasciatus* (L.)	Five-lined skink, "scorpion"	Cope 1900, 632*
78.	*E. humilis* Boul.	Pecos skink	Boulenger 1887, 377
79.	*E. multivirgatus* (Hallow.)	Many-lined skink	Cope 1900, 653*
80.	*E. obsoletus* (B. and G.)	Gray skink, Sonoran skink	Burt 1929, 2*
81.	*E. septentrionalis* (Baird)	Prairie skink	Cope 1900, 656*
82.	*E. skiltonianus* (B. and G.)	Western skink	Van Denb. 1922, 578*
83.	*E. tetragrammus* (Baird)	Texan stone skink	Cope 1900, 660*
84.	*Neoseps reynoldsi* Stej.	Burrowing skink	Stejneger 1910, 34*
	G. Family Amphisbaenidae		
85.	*Rhineura floridana* (Baird)	Florida worm lizard	Cope 1900, 686*

H. Family Helodermatidae

Classification	Common name	Description
86. *Heloderma suspectum* Cope	Sonoran gila monster	Van Denb. 1922, 471*

I. Family Anguidae

Classification	Common name	Description
87. *Gerrhonotus coeruleus coeruleus* Wieg.	San Franciscan alligator lizard	Van Denb. 1922, 440 (pt.)
88. *G. c. palmeri* Stej	Mountain alligator lizard	Van Denb. 1922, 445
89. *G. c. principis* (B. and G.)	Northern alligator lizard	Cope 1900, 529*
90. *G. c. shastensis* Fitch	Shasta alligator lizard	Fitch 1934, 6
91. *G. infernalis* Baird	Texas alligator lizard	Cope 1900, 517*
92. *G. kingii* Gray	Sonoran alligator lizard	Cope 1900, 519*
93. *G. multi-carinatus multi-carinatus* Blainv.	Western alligator lizard	Fitch 1934, 172
94. *G. m. scincicauda* (Skil.)	Oregonian alligator lizard	Van Denb. 1922, 450*
95. *G. m. webbii* Baird	San Diegan alligator lizard	Van Denb. 1922, 455*
96. *Barissia levicollis* Stej	False alligator lizard	Cope 1900, 535*
97. *Ophisaurus ventralis* (L.)	Joint lizard or "glass snake"	Cope 1900, 494*

J. Family Anniellidae

Classification	Common name	Description
98. *Anniella nigra* Fischer	Black footless lizard	Van Denb. 1922, 467*
99. *A. pulchra* Gray	Silvery footless lizard	Van Denb. 1922, 465*

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ALPHABETICAL LIST OF LIZARDS OF UNITED STATES AND CANADA

Anniella nigra
pulchra
Anolis carolinensis
stejnegeri
Barissia levicollis
Callisaurus draconoides ventralis
notatus
Cnemidophorus hyperythrus hyperythrus
sexlineatus perplexus
sexlineatus sackii
sexlineatus sexlineatus
tessellatus tessellatus
Coleonyx brevis
variegatus
Crotaphytus collaris
reticulatus
silus
wislizenii
Ctenosaura acanthura
Dipso-saurus dorsalis dorsalis
Eumeces anthracinus
brevilineatus
callicephalus
egregius
fasciatus
humilis
multivirgatus
obsoletus
septentrionalis
skiltonianus
tetragrammus
Gerrhonotus coeruleus coeruleus
coeruleus palmeri
coeruleus principis
coeruleus shastensis
infernalis
kingii
multi-carinatus multi-carinatus

multi-carinatus scincicauda
multi-carinatus webbii
Heloderma suspectum
Hemidactylus turcicus
Holbrookia maculata lacerata
maculata lacerata
maculata maculata
maculata propinqua
texana
Lacerta melisellensis fiumana
Leiolopisma unicolor
Neoseps reynoldsi
Ophisaurus ventralis
Phrynosoma coronatum blainvillii
coronatum frontale
cornutum
ditmarsi
douglassii douglassii
douglassii hernandesi
m'callii
modestum
platyrhinos
solare
Phyllodactylus tuberculosus
Rhineura floridana
Sauromalus obesus
Sceloporus clarkii clarkii
couchii
disparilis
graciosus gracilis
graciosus graciosus
graciosus vandenburgianus
jarrovii
merriami
orcutti
ornatus
scalaris
spinosus
torquatus poinsettii
undulatus becki
undulatus bi-seriatus
undulatus consobrinus
undulatus elongatus
undulatus floridanus
undulatus occidentalis
undulatus taylori
undulatus undulatus
undulatus woodi
variabilis marmoratus
Sphaerodactylus cinereus
notatus
Uta graciosa
levis
mearnsi
microscutata
ornata ornata
ornata symmetrica
stansburiana
Xantusia arizonae
henshawi
riversiana
vigilis

A Study of the Blood Pictures of Rabbits Subjected to Tobacco and Other Smokes

MARY GARLOCK, Kansas State Teachers College, Pittsburg, Kan.

The prevalence of smoking and its apparent increase since the World War has led to many investigations to determine what injury might occur in the smoker (Sanguinetto, 1930; Grollman, 1930; Mertens, 1930; Bosco, 1930; Herrick, 1931; Thompson, 1934; Sontag-Wallace, 1935; and many others). The great variety of the methods, results, and interpretations given in these reports leaves considerable doubt as to the actual effects of tobacco smoke on the human body. Thus it seems that, if more definite information is to be secured, some different method of approaching the subject should be tried.

Since many types of injuries are manifested by changes in the blood picture, one is led to suspect that a study of such changes might yield some definite indications as to the effect of smoking. Because experiments with laboratory animals are more easily controlled than similar experiments with human beings, it was decided to carry out a study of the blood picture of rabbits subjected to smoke.

THE PROBLEM

The problem as investigated in this study consists of the determination of the hemoglobin content, the total white cell count, the red cell count, and the differential white cell count of rabbits immediately before and after treatment with smoke.

LITERATURE

In a review of the literature, no studies relating to this particular problem were found, although Walters (1934) in a report of tests made at random on smokers and nonsmokers, stated that he found no significant difference in the hemoglobin and red cell counts of these two groups.

Some of the available reports (Bushnell and Bangs, 1926; Pearce and Casey, 1930; Vedder, 1930; Scarborough, 1930) provide pertinent data on the normal blood picture of relatively large numbers of animals. On the whole, the results given are fairly consistent, although the terminology used in the classification of white cells differs in certain instances. Many of the workers deny the existence of a true neutrophile in the blood of rabbits and substitute for this group a class which they call pseudo-eosinophiles. Some authors reported monocytes while others proposed additional classes, such as lymphocyt-monocyts, and transitional forms.

METHODS AND APPARATUS

The red and white cell counts were made in the usual way and the hemoglobin was determined by means of the Sahli method. The differential white cell count was made with Wright's stain and the cells were grouped according to the most widely accepted classification, namely, lymphocytes, pseudo-eosinophiles, eosinophiles, basophiles, and monocytes.

Previous to the beginning of the experiment tests were made on a number of rabbits to determine whether or not the normal blood picture of our animals varied materially from those reported by other investigators.

TABLE I.—Results of determinations of blood pictures of rabbits during preliminary and test experiments with tobacco smoke, string smoke, and no smoke

No. of tests made.	TREATMENT.	Hemoglobin.	White cells.	Red cells.	Differential white-cell count.				
					Lymphocytes.	Eosinophiles.	Pseudoeosinophiles.	Monocytes.	Basophiles.
21	Preliminary tests	73	7,277	5,027,000	73.4	6.2	16.7	1.1	0.4
180	Tobacco smoke:								
	A	68.2	7,146	4,548,000	71.2	3.9	21.8	2.0	0.7
	B	72.8	5,593.2	4,988,000	48.8	4.5	44.2	2.01	0.8
	Change	+4.6	—1,552.8	—440,000	—22.4	+0.6	+22.4	—0.01	—0.1
	P. E.	0.71	127.8	44,872	0.978	0.308	0.84	0.162	.065
	S. D*	3.0	7.7	8.3	9.3	....	9.6	....	....
80	String smoke:								
	A	83.1	7,372	467,250	79.4	1.45	17.75	1.2	0.3
	B	83.3	5,129	377,000	67.5	2.60	28.15	1.5	0.5
	Change	+0.2	—1,243	—90,250	—11.9	+1.2	+10.4	+0.3	+0.2
	P. E.	.669	177.34	387,000	1.09	0.234	0.91	0.138	0.06
	S. D*	....	5.6	....	6.4	....	2.6	....	....
120	Control:								
	A	70.3	6,666	4,887,000	73.7	6.5	19.4	0.7	1.0
	B	69.7	6,866.5	4,779,000	68.2	6.9	24.8	1.1	0.9
	Change	—0.6	+200.5	—108,000	—5.5	+0.4	+5.4	+0.4	—0.1
	P. E.	1.86	193.8	65,780	1.51	0.575	1.68	0.048	0.129

A, Before treatment. B, After treatment. P. E., Probable error * S. D., Significant difference based on control. (Three or more considered significant, two or three of doubtful significance.)

The smoking was done in a chamber devised from a sixty-gallon steel tank with standard brands of cigarettes. The smoke was introduced into the chamber by blowing from a lighted cigarette held in a small opening at one end of the tank and covered with a small glass cylinder to which a rubber tube was attached for blowing. A similar opening at the opposite end of the tank allowed the escape of smoke when the tank became filled. Normal adult rabbits were used.

Three times daily for one hour each rabbit was subjected to the smoke of one cigarette, with one hour rest intervals between the smoking periods. With each rabbit the experiment was repeated on each of ten consecutive days, and the blood picture was taken immediately before and after the smoke treatments each day.

In order to make certain that the lack of oxygen or other factors involved with confinement in the chamber was not responsible for the changes which might occur, one series of controls was treated in exactly the same manner as the series smoked except that no smoke was introduced into the chamber. Another group of controls in which string smoke was substituted for tobacco smoke was used to indicate whether or not another smoke might have a similar effect.

RESULTS

In the accompanying table are presented the results of the preliminary tests to determine the normal blood picture for the rabbits used, the average obtained before and after treatment with tobacco smoke, with string smoke, and without any smoke, and the average change, probable error and the so-called "significant change" for each series.

The averages obtained from preliminary tests made in an attempt to establish a normal do not vary materially from the normals for the blood picture of rabbits as given by other investigators, with the exception that the percentage of lymphocytes is slightly higher and the percentage of pseudo-eosinophiles is correspondingly lower than the percentages commonly reported.

It will be noted from a study of this table (Table I) that there is a notable increase in hemoglobin, red cells, and in the percentage of pseudo-eosinophiles, and a decrease in the white cells and in the percentage of lymphocytes, with no significant change in the other types of white cells. Also it is evident that there is a fall in the white count and in the percentage of lymphocytes, and a rise in pseudo-eosinophiles, but no significant change in the red count and hemoglobin content when rabbits are treated with cigarette smoke. The results shown appeared consistently in the tests of all the animals as well as in the averages of all the tests. The series treated with string smoke, similarly show a decrease in the white count and lymphocytes and an increase in pseudo-eosinophiles, but no significant changes in the red count and the hemoglobin content. In the control group in which no smoke was used, not only did the averages show no significant change, but the minor fluctuations which did occur were inconsistent in direction as well as in size. Changes were not considered important unless they were at least five times the probable error.

SUMMARY

1. Rabbits treated with tobacco smoke in the manner described showed a consistent rise in the hemoglobin content, red cell count, and the percentage of pseudo-eosinophiles. Likewise they showed a fall in the white cell count and in the percentage of lymphocytes.

2. Rabbits treated with string smoke showed a decrease in the white cell count and in the percentage of lymphocytes and an increase in pseudo-eosinophiles. No significant changes occurred in the hemoglobin content or in the red cell count.

3. A control series of rabbits showed no significant changes in the blood picture.

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The Birds of Southeastern Kansas, with Migration Dates

By HARRY H. HALL, Kansas State Teachers College, Pittsburg, Kan.

For the past eight years the writer has undertaken a study of the birds of southeastern Kansas. Numerous trips have been made to the eleven counties which comprise this district. In Crawford county observations of rather painstaking character have extended throughout the period.

Habitats range from ponds, lakes, prairies, thickets to forests. There are thickets of plum, sumac, elder and thornapple. Along the streams may be found the maple-ash-oak association.

The mean annual temperature for the three summer months is 78° F.; for the three winter months, 35°. The mean annual precipitation is 40 inches. The average date of first killing frost, October 21; average date of last killing frost, April 10. The area has a growing season of 193 days.

In the list of birds here enumerated are the species which have been seen or collected by the writer during the period from September, 1927, to March, 1935. Permanent residents are designated and the average date of arrival and disappearance of the migratory species is stated. The nomenclature of the American Ornithologists' Union Checklist and its supplements has been followed.

The 208 species of birds which have been identified are distributed among the following seventeen orders: Gaviiformes, 1; Colymbiformes, 1; Pelecaniformes, 2; Ciconiiformes, 7; Anseriformes, 26; Falconiformes, 15; Galliformes, 3; Gruiformes, 6; Charadriiformes, 20; Columbiformes, 2; Cuculiformes, 2; Strigiformes, 8; Caprimulgiformes, 2; Micropodiformes, 2; Coraciiformes, 1; Piciformes, 7; and Passeriformes, 103.

Of the 208 species and subspecies, 28 are residents, either nonmigratory birds nesting in the southeastern part of Kansas or migratory birds occurring in both summer and winter; 79 are summer breeding species; 5 are winter visitants; 64 are spring and fall transients; and 32 are of casual occurrence.

WATER AND SHORE BIRDS

	Average time of arrival	Average time of departure
Common loon	Apr. 10	?
Pied-billed grebe	Mar. 20	Sept. 28
White pelican	Mar. 12	?
Double-crested cormorant	Mar. 22	?
Great blue heron	Mar. 29	Sept. 6
American egret	Apr. 12	?
Snowy egret	Apr. 3	?
Little blue heron	Apr. 12	?
Eastern green heron	Apr. 3	Oct. 28
Black-crowned night heron	Apr. 9	Oct. 4
American bittern	Apr. 6	Apr. 30
Whistling swan	Irregular	
Canada goose	Feb. 7	Mar. 25
Hutchins goose	Mar. 7	Apr. 18
American brant	Mar. 14	?
White-fronted goose	Feb. 25	Mar. 12
Lesser snow goose	Feb. 21	Mar. 4

	Average time of arrival	Average time of departure
Greater snow goose	Feb. 20	Apr. 1
Common mallard	Feb. 2	Apr. 20
Gadwall	Feb. 28	Mar. 29
Baldpate	Mar. 1	Apr. 2
American pintail	Feb. 1	Apr. 10
Green-winged teal	Feb. 27	Apr. 10
Blue-winged teal	Feb. 28	Apr. 7
Shoveler	Mar. 14	Apr. 12
Wood duck	Mar. 27	?
Redhead	Mar. 6	Mar. 28
Ring-necked duck	Mar. 29	Apr. 20
Canvasback	Feb. 20	Mar. 12
Greater scaup duck	Mar. 1	Apr. 1
Lesser scaup duck	Feb. 15	Mar. 29
American golden-eye	Irregular	
Bufflehead	Irregular	
White-winged scoter	Irregular	
Ruddy duck	Irregular	
Hooded merganser	Mar. 6	?
American merganser	Mar. 12	Apr. 12
Sandhill crane	Irregular	
King rail	Apr. 18	July 29
Virginia rail	Apr. 6	Aug. 12
Sora	Apr. 12	May 7
Florida gallinule	Apr. 1	Apr. 10
American coot	Mar. 2	Aug. 12
Semipalmated plover	Apr. 12	May 20
Killdeer	Feb. 18	Sept. 20
Golden plover	Apr. 8	?
Woodcock	Resident	
Wilson snipe	Mar. 5	May 25
Upland plover	Mar. 28	May 10
Spotted sandpiper	Apr. 10	Aug. 13
Solitary sandpiper	Apr. 7	May 12
Greater yellow-legs	Mar. 28	Apr. 20
Lesser yellow-legs	Mar. 27	May 25
Pectoral sandpiper	Apr. 27	June 14
Baird sandpiper	Apr. 12	June 15
Least sandpiper	Apr. 5	June 10
Semipalmated sandpiper	Apr. 1	May 29
Herring gull	Feb. 25	Apr. 12
Ring-billed gull	Mar. 2	?
Franklin gull	Apr. 10	Apr. 24
Forster tern	Apr. 7	?
Common tern	May 26	?
Black tern	Apr. 27	?

LAND BIRDS

Turkey vulture	Mar. 5	Oct. 28
Goshawk	Irregular	
Sharp-shinned hawk	Mar. 10	Nov. 16
Cooper's hawk	Mar. 7	Oct. 12
Eastern red-tailed hawk	Resident	
Red-shouldered hawk	Resident	
Broadwinged hawk	Apr. 12	Nov. 10
Swainson hawk	Apr. 20	Oct. 12
Ferruginous rough-legged hawk	Oct. 28	Mar. 20

	Average time of arrival	Average time of departure
American golden eagle	Aug. 12	?
Southern bald eagle	June 24	?
Marsh hawk	Mar. 7	May 25
Prairie falcon	Resident	
Duck hawk	May 20	?
Eastern sparrow hawk	Resident	
Prairie chicken	Resident	
Bobwhite	Resident	
Ring-necked pheasant	Resident	
Eastern mourning dove	Mar. 5	Oct. 28
Domestic pigeon; rock dove	Resident	
Yellow-billed cuckoo	Apr. 27	Sept. 28
Black-billed cuckoo	Apr. 25	Sept. 20
Barn owl	Resident	
Eastern screech owl	Resident	
Southern screech owl	Aug. 20	?
Great horned owl	Resident	
Snowy owl	Aug. 20	?
Northern barred owl	Resident	
Long-eared owl	Resident	
Short-eared owl	Oct. 7	Mar. 15
Eastern whippoorwill	Apr. 8	Oct. 27
Eastern nighthawk	Apr. 26	Oct. 2
Chimney swift	Apr. 8	Oct. 27
Ruby-throated hummingbird	Apr. 27	Oct. 6
Eastern belted kingfisher	Mar. 7	Nov. 20
Flicker	Mar. 29	Nov. 12
Pileated woodpecker	Resident	
Red-bellied woodpecker	Resident	
Red-headed woodpecker	Apr. 12	Nov. 15
Yellow-bellied sapsucker	Mar. 29	Apr. 15
Eastern hairy woodpecker	Resident	
Northern downy woodpecker	Resident	
Kingbird	Apr. 18	Sept. 26
Crested flycatcher	Apr. 29	Sept. 25
Phoebe	Mar. 9	Oct. 27
Wood pewee	Apr. 28	Oct. 13
Acadian flycatcher	May 1	Oct. 5
Least flycatcher	Apr. 27	May 20
Horned lark	Resident	
Blue jay	Resident	
Crow	Resident	
Bobolink	May 5	Aug. 12
Cowbird	Mar. 2	Nov. 25
Red-winged blackbird	Feb. 27	Nov. 26
Meadow lark	Feb. 28	Nov. 27
Orchard oriole	Apr. 12	Oct. 22
Baltimore oriole	Apr. 20	Oct. 28
Rusty blackbird	Mar. 1	Aug. 12
Bronzed grackle	Mar. 4	Nov. 8
Purple finch	Apr. 12	Aug. 12
Common redpoll	Mar. 26	?
Goldfinch	Resident	
Pine siskin	Irregular	
English sparrow	Resident	
Vesper sparrow	Mar. 6	May 12
Savannah sparrow	Mar. 12	Aug. 3
Lark sparrow	Apr. 2	Sept. 28

	Average time of arrival	Average time of departure
Grasshopper sparrow	Apr. 15	Nov. 2
Henslow sparrow	Apr. 18	Oct. 17
LeConte sparrow	Feb. 28	Mar. 5
Harris sparrow	Mar. 1	Sept. 26
White-crowned sparrow	Mar. 12	Aug. 12
White-throated sparrow	Apr. 1	Apr. 28
Tree sparrow	Nov. 1	Apr. 20
Chipping sparrow	Mar. 10	Oct. 25
Oregon junco	Apr. 2	May 20
Slate-colored junco	Nov. 4	Mar. 26
Song sparrow	Mar. 7	Apr. 28
Lincoln sparrow	Apr. 1	May 12
Swamp sparrow	Mar. 9	Apr. 27
Field sparrow	Mar. 7	Sept. 26
Fox sparrow	Feb. 27	Apr. 10
Towhee	Mar. 5	Oct. 26
Cardinal	Resident	
Rose-breasted grosbeak	Apr. 10	Oct. 20
Eastern blue grosbeak	Apr. 27	Oct. 5
Indigo bunting	Apr. 20	Oct. 16
Dickcissel	Apr. 14	July 3
Scarlet tanager	Apr. 29	Oct. 16
Summer tanager	Apr. 25	Oct. 12
Purple martin	Mar. 12	Oct. 24
Cliff swallow	Apr. 12	?
Barn swallow	Apr. 7	Oct. 2
Bank swallow	May 1	Sept. 27
Tree swallow	Apr. 10	May 4
Rough-winged swallow	Apr. 20	Sept. 27
Cedar waxwing	Apr. 12	June 12
Northern shrike	Mar. 12	Oct. 15
Loggerhead shrike	Mar. 25	Sept. 12
Red-eyed vireo	Apr. 17	Sept. 27
Warbling vireo	Apr. 9	Sept. 26
Yellow-throated vireo	Apr. 12	Sept. 20
Blue-headed vireo	Apr. 20	June 3
White-eyed vireo	Apr. 20	Sept. 25
Bell's vireo	Apr. 28	Sept. 27
Black-and-white warbler	Apr. 12	Sept. 24
Prothonotary warbler	Apr. 29	Sept. 28
Blue-winged warbler	May 12	?
Worm-eating warbler	Apr. 8	Sept. 19
Tennessee warbler	Apr. 9	Sept. 12
Nashville warbler	Apr. 20	May 20
Orange-crowned warbler	Apr. 20	May 20
Parula warbler	Apr. 8	Sept. 28
Yellow warbler	Apr. 9	Aug. 20
Myrtle warbler	Mar. 29	Oct. 28
Cerulean warbler	May 1	Sept. 10
Yellow-throated warbler	May 2	Sept. 18
Black-poll warbler	May 3	May 12
Oven bird	Apr. 28	Oct. 16
Louisiana water-thrush	Apr. 11	Oct. 1
Kentucky warbler	May 1	Sept. 2
Mourning warbler	May 3	July 3
Maryland yellow-throat	Apr. 16	Sept. 20
Yellow-breasted chat	Apr. 15	Sept. 17
American redstart	Apr. 23	Oct. 16

	Average time of arrival	Average time of departure
Mockingbird	Apr. 10	Oct. 17
Catbird	Apr. 27	Oct. 4
Brown thrasher	Apr. 1	Oct. 12
Carolina wren	Resident	
Short-billed marsh wren	Apr. 27	Sept. 25
House wren	Apr. 15	Oct. 2
Brown creeper	Nov. 10	Apr. 30
Red-breasted nuthatch	Apr. 20	May 25
White-breasted nuthatch	Resident	
Tufted titmouse	Resident	
Chickadee	Resident	
Golden-crowned kinglet	Apr. 12	Apr. 27
Ruby-crowned kinglet	Mar. 28	May 10
Blue-gray gnatcatcher	Apr. 1	Sept. 12
Wood thrush	Mar. 20	Sept. 27
Gray-cheeked thrush	Apr. 1	June 1
Olive-backed thrush	Apr. 1	June 5
Hermit thrush	Mar. 20	Apr. 15
Robin	Feb. 1	Nov. 1
Bluebird	Feb. 1	Oct. 27

The Occurrence of Phrynosoma coronatum frontale in Montana

. M. J. HARBAUGH, Kansas State College, Manhattan, Kan.

A specimen of *Phrynosoma coronatum frontale*[1] was captured August 22, 1934, in dry, sparse vegetation at the base of Mt. Sentinel, near the city limits of Missoula, Mont.

Specifications: body, 90 mm.; tail, 35 mm.; ear to snout, 15 mm.; width of head, 26 mm.; occipital spines, 10 mm.; hind limb, 46 mm.; eight rows of enlarged gular scales, the two mesial rows spineless and small, the two outer rows large and spinose; the outermost row on each side curves laterally and dorsally and ends at the posterior margin of first group of neck spines (this differs from the description given by Cope[2] which states that the outermost row ends on the gular folds); three rows of spinose scales across the anterior pectoral region; head spines and subrictals tinted with orange red; one small interoccipital; a row of five spinose scales immediately anterior to the occipitals; ventral side yellow with dark brown to black blotches, some of which are confluent to form irregular bars.

When captured the animal gently emitted a few drops of blood from each eye. The blood trickled down the sides of the head to the upper labials. This action agrees with the findings of Van Denburgh.[3] Bailey[4] and Hay[5] both found that blood was ejected forcibly for a considerable distance, the maximum being 15 inches. Bailey further states that the animal ejected blood from each eye four or five times in succession. With the specimen which I had no amount of rough handling could induce it to repeat the phenomenon in less than four hours. The eyelids of this species are highly vascular and contain large sinuses which become greatly distended with blood, the ejection of which is probably attained by the rupturing of a vessel. Because of the ability of these lizards to "weep tears of blood" they are known to the Mexicans as "sacred toads."

Previously this lizard has not been taken outside the limits of California and there is a possibility that they are not indigenous to Montana, the presence of this specimen being explainable on the basis of accidental dispersal.

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1. Grateful acknowledgment is hereby made to Dr. C. E. Burt, of Southwestern College, Winfield, Kan., for valuable aid and constructive criticism during the identification of this specimen.

2. Annual Report of the Smithsonian Inst. 1897-'98, p. 480.

3. Occas. Pap. Calif. Acad. Sci. 10(1), 1922, p. 400.

4. N. Amer. Fauna, No. 7, 1895, p. 189.

5. Proc. U. S. Nat. Mus. XV, 1892, p. 375.

Parthenogenesis in the Ovaries of Guinea Pigs

MARY T. HARMAN, Kansas State College, Manhattan, Kan.

It is not a new thing to find segmenting eggs in the ovaries of guinea pigs. Loeb (1912) described structures in the ovaries of guinea pigs which he said he thought were the result of parthenogenetic development. In 1923 he said, "A relatively far-going parthenogenetic development of eggs in the ovary of a guinea pig has been observed by us so far in thirty animals. It can therefore not be considered an exceptional occurrence."

Again (in 1932) he described four cases and further stated that the number observed had increased to forty-five. In most cases these were of animals which had been used for experimental purposes. He had had some on starvation diet and others he had injected with one or another hormone. However, he described one case which occurred in one of his control animals.

Courrier and Oberling (1923), Courrier (1923), Branca (1925), Lelievre, Peyron, and Corsy (1927) have observed structures similar to those which Loeb has observed, but in each case it was in pathological individuals. Squier (1932) said that Mrs. Lewis had found one egg dividing parthenogenetically among those which she was observing in tissue culture.

In our combined work on the normal embryology of the guinea pig we have sacrificed over two hundred mothers. These mothers have been in various stages of pregnancy from seven days to almost term. Besides these we have killed a great many nonpregnant females. All of these animals had been kept under as favorable conditions as we could provide and the food was as nearly a normally balanced ration as we knew how to prepare. The food was the same as that which has been used in the genetic experiments carried on by Doctor Ibsen. In fact, the grain mixture already combined was obtained from Doctor Ibsen. We supplemented this with straw, alfalfa hay and either fresh alfalfa or sprouted oats. We preserved the ovaries of the greater number of these animals. In addition to these ovaries we have had the ovaries of a number of the guinea pigs which we have fed on a limited diet.

Now we have been devoting some time to the examination of these ovaries. Up to the present time more than fifty of the ovaries from animals having normal food have been examined, and in every ovary, without exception, we have found eggs within Graafian follicles either in the polar body formation or in various stages of segmentation or both. The polar body formations are in almost all stages. Some are in a metaphase of the first polar spindle while others are clearly in the process of the second maturation. In these evident cases of second polar body formation the first polar body is seen attached to the egg. The segmenting eggs range from the two-celled stage to a well-formed morula. The maturation divisions are easily distinguished from the segmentation divisions. The maturation spindle is small and near the periphery of the egg, while the segmentation spindle, when present, is in the center of the cell. The length of the spindle is determined by the size of the cell. There is practically no rhythm in segmentation and the morula is composed of cells of various sizes. In a previous paper, Harman and Brill, 1933, we mentioned finding polar spindles in eggs of vitamin-C deficient animals. Our

observations thus far seem to indicate that the condition is no more frequent in the experimental animals than in the others.

Loeb has described connective-tissue formation and atresia in the follicles containing the developing ova. He has also described the lutenization of the granulosa cells. We have found this condition, also, but in addition we have found the segmenting ova in follicles in which we have been unable to observe any indication of atresia, necrosis or other degenerative processes.

We are not ready to draw any conclusions concerning the significance of these phenomena, but wish to emphasize the fact of the universal occurrence of maturation divisions or segmentations, or both, in supposedly normal animals as well as in the experimental ones.

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Some Effects of Experimental Diets Upon the Reproduction and Growth of the Guinea Pig (Cavia cobaya)

ABSTRACT

MARY T. HARMAN and ISABELLE GILLUM, Kansas State College, Manhattan, Kan.

The Sherman, LaMer and Campbell vitamin-C-free diet was fed to guinea pigs. A high grade of filter paper was supplied for roughage. Greens were used as a supplement for the control animals and orange juice as the source of vitamin C for the experimental groups. The negative control animals received no antiscorbutic supplement.

In the control group 24 females produced 69 young which averaged 105 grams at birth. The average litter size was 2.88.

Animals where orange juice ad libitum was the supplement produced young successfully in three or four cases. Their young averaged 81 grams and the litter size 2.33. Neither 5 cc. nor 10 cc. orange juice per 300 grams body weight given by pipette to pregnant animals was an adequate supplement in 5 cases. The same was true for one female given orange juice by pipette when yeast was added to the basal diet. Abortions took place between 46 and 61 days.

One young negative control animal died of scurvy in 41 days, at which time the others were killed.

After pregnancy females retained on greens as supplement gained considerably in weight in six weeks whereas those retained on orange juice as supplement for the same period gained but very little. One female on greens as supplement accepted a male the day of giving birth to three. She and her young were the negative control animals. In 20 days the mother aborted and three days later died. She had lost 312 grams.

Gains in weight for young placed on a supplement of greens were much greater than gains for animals on supplements of orange juice.

Some Observations on the Development of the Teeth of Cavia cobaya

ABSTRACT

MARY T. HARMAN and ARLENE SMITH, Kansas State College, Manhattan, Kan.

The guinea pig has been used as an experimental animal to observe the effects of vitamin C deficiency. Since the condition of the teeth is one of the diagnostic characteristics of scurvy, it is well to know the normal development of the teeth. The guinea pig is born with its teeth ready to function. There is some difference of opinion among investigators concerning the matter of deciduous teeth in the guinea pig and also about how the cheek teeth make their appearance. There is lack of agreement about the number of molars and premolars. Instead of taking sides on this last point of contention we have chosen to call the molars and premolars cheek teeth.

The dental formal of the guinea pig is: incisors $1/1$, canines $0/0$, cheek teeth $4/4$. There is one deciduous tooth in each half jaw, located between the first and second cheek tooth near the outer surface of the jaw. These are resorbed in utero.

The enamel organs begin forming between twenty and twenty-five days, and are cut through the gums by fifty-five days. They erupt in the following order: incisors, second cheek tooth, third cheek tooth, first cheek tooth and finally the fourth cheek tooth. All the teeth are rootless and continue to grow as their surfaces are worn down. The enamel is formed on the anterior surfaces of the incisors and the sides of the cheek teeth.

The cheek teeth are compound teeth. Each one is composed of an anterior and a posterior portion. The anterior portion is the larger and develops in advance of the posterior portion. Fusion gradually takes place as the single cones enlarge. At the time of eruption the dental pulp and the dentine of the two parts are continuous at the base. The two parts are firmly united at about thirty or forty days post natal life.

Origin and Development of the Crop in the Chick

M. W. MAYBERRY, University of Kansas, Lawrence, Kan.

This investigation as to the origin and development of the crop in the chick has been undertaken because of the statement in Lillie's[1] text, that no detailed account of its development exists. He states, "The crop arises as a spindle-shaped dilation of the oesophagus at the base of the neck; on the eighth day it is about double the diameter of the parts immediately in front and behind it."

Throughout this investigation eggs from Plymouth Rock hens have been used. Six eggs per day on the average were taken from the incubator, beginning with the seventh day on through the twenty-first day, for the purpose of observing the gross morphological and microscopical developments. Sections of the adult crop have also been made in order to study its structure. The dissections during the incubation period were made of the greater portion of the esophagus and also included the gizzard. Material to be sectioned was fixed in picro-formalin solution and embedded in paraffin. The serial sections were stained with Delafield's haematoxylin and eosin. Those sections which were to be photomicrographed were mounted in hyrax.

Dissections of the digestive tract of chicks incubated seven days show the esophagus with a slight bend to the right in the region of the seventh cervical vertebra (Fig. 17). The bend indicates the position of evagination which becomes more prominent in the eighth day of incubation (Figs. 13, 18). Sections taken in this region show the entodermic cells differentiated into an epithelium consisting of from two to three layers of cuboidal cells while the mesodermic elements remained comparatively undifferentiated. Serial sections indicate a slight increase in the cross diameter of the lumen at the locus of bending. At this point the lumen measures 0.24 mm. across, while above or below this region the lumen measures 0.16 mm.

The digestive tract taken from chicks incubated eight days shows a more definite superficial swelling at the place of bending (Fig. 18). The epithelium remains as found on the seventh day, but the mesenchymal cells are becoming transformed into myoblasts. The wall of the esophagus has become decidedly convoluted excepting in the crop region where the lumen shows a slight increase in cross diameter over that of the seventh day, measuring approximately 0.35 mm. (Figs. 1, 13).

In nine-day chicks the crop evagination is considerably enlarged, measuring approximately 1.6 mm. across at the widest diameter (Fig. 19). The evagination is definitely towards the right side of the embryo. Serial sections show that the lumen of the crop averages 1.3 mm. across while the esophagus outside the crop region measures 0.16 mm. The enlargement of the lumen has been comparatively rapid without further noticeable tissue differentiation or growth in thickness of the wall. The mucosa is still smooth except on the side opposite the evagination and here two prominent convolutions are seen.

1. Lillie, F. R. "The Development of the Chick, an Introduction to Embryology." Third Edition. Blakiston's Son and Co.

Observations of crops taken from chicks of ten to seventeen days incubation show a slight but steady increase in size (Figs. 20-25). An average crop from chicks on the tenth day measures 3 mm. across at its widest diameter, while at the sixteenth day the average crop measures 5 mm. across.

Sections of crops from chicks incubated ten days indicate a decided thinning of the evaginated wall (Figs. 2, 14). The thinner wall is approximately .04 mm. thick while the thicker wall averages 0.16 mm. No convolutions have appeared in the evaginated wall. The epithelial layer of the evagination is composed of two rows of cuboidal cells; on the opposite wall it is approximately four rows thick. The differentiation of the muscularis is most prominent in the nonevaginated wall, while in the evaginated wall it is developing in streaks.

Slight convolutions of the evaginated wall have appeared during the thirteenth and fourteenth days. A noticeable proliferation of the epithelium has occurred. It is now composed of from five to eight cell rows with the cells still cuboidal except in the basement epithelium where they appear columnar. The muscularis can easily be distinguished as being composed of two muscle layers, an outer longitudinal and an inner circular layer. The circular muscle layer is comparatively the heavier layer. The muscularis mucosa can be made out in the mucosa.

During the fifteenth and sixteenth days a more pronounced folding of the mucosa takes place. The following layers can easily be distinguished, naming from the lumen outward through the wall: epithelium, stroma, muscularis mucosa, submucosa, circular muscles, longitudinal muscles and serous coat. Glands have also formed within the mucosa of the wall opposite the evagination but not in the evaginated wall itself. The glands develop as tubular downgrowths which pass into the mucosa and there expand into lumina which average 0.06 mm. in cross diameter. The necks of the glands are straight, slender tubes with a narrow lumen.

In sections taken of crops during the seventeenth and eighteenth days the wall of the crop evagination is much thicker due to the heavy foldings of the mucosa (Fig. 5) and development of the muscularis.

Mounts of crops taken from chicks on the twentieth and twenty-first days of incubation show an average cross diameter of 8 mm. (Figs. 16, 28). The position is still towards the right side of the chick. The histological difference shown by sections is in the mucosa (Fig. 6). The epithelium now consists of several superimposed cell layers. The cells of the basement epithelium are columnar and closely crowded while towards the free surface the cells become gradually flattened, forming a stratified squamous epithelium typical of the adult crop. The rapid dilation of the crop from the seventeenth and eighteenth days to the twentieth has not been accompanied by an increase in the muscularis. The circular muscles appear more diffuse due to the dispersal of connective-tissue cells within the layer (Fig. 6). The glands present are found in the nonevaginated wall and show no advance development over those of the seventeenth day (Figs. 10, 11).

A full-grown crop undistended has an average diameter of approximately 2.5 cm. The greater portion of the evaginated wall is comparatively thin without rugae (Figs. 7, 29b), while an area on the lower side continuous with

the esophageal wall is noticeably thicker (Figs. 8, 29a). The region is moderately rugose. There are numerous pits in the nonevaginated wall of the crop which microscopic examination shows are glands (Figs. 9, 29c). The glands, as indicated throughout the embryological development, are limited to the esophageal wall.

Sections taken through the wall of the thinner-walled area of the crop average 0.7 mm. in thickness while in the thicker-walled area the average thickness is 1.35 mm. (Figs. 7, 8). The muscularis is comparatively less developed in the major portion of the crop wall, but in the thicker area where the mucosa is rugose the muscularis is composed of a heavy band of circular muscles and an outer longitudinal muscle (Fig. 8). The stratified squamous epithelium has increased greatly in number of cell layers while superficial cells are sloughing off (Figs. 8, 9).

Glands of the adult crop are considerably increased in size over those at the close of the period of incubation, having lumina approximately 0.6 mm. in cross diameter. The glands are embedded within the mucosa (Fig. 12). The ostioles average 0.15 mm. across.

PLATE I

(Photomicrographs)

Sections of the evaginated wall of the chick's crop at various stages of incubation and adult development.

Fig. 1. Eighth day.
Fig. 2. Tenth day.
Fig. 3. Thirteenth day.
Fig. 4. Fifteenth day.
Fig. 5. Seventeenth day.
Fig. 6. Twenty-first day.

PLATE I

PLATE II

(Photomicrographs)

Sections of the evaginated wall of the chick's crop at various stages of incubation and adult development.

Fig. 7. Adult (from thinner-walled area).
Fig. 8. Adult (from thicker-walled area).
Fig. 9. Adult (sloughing epithelium).
Fig. 10. Gland in the mucosa at the seventeenth day.
Fig. 11. Glands in the mucosa at the twenty-first day.
Fig. 12. Gland in the mucosa from the adult crop.

PLATE II

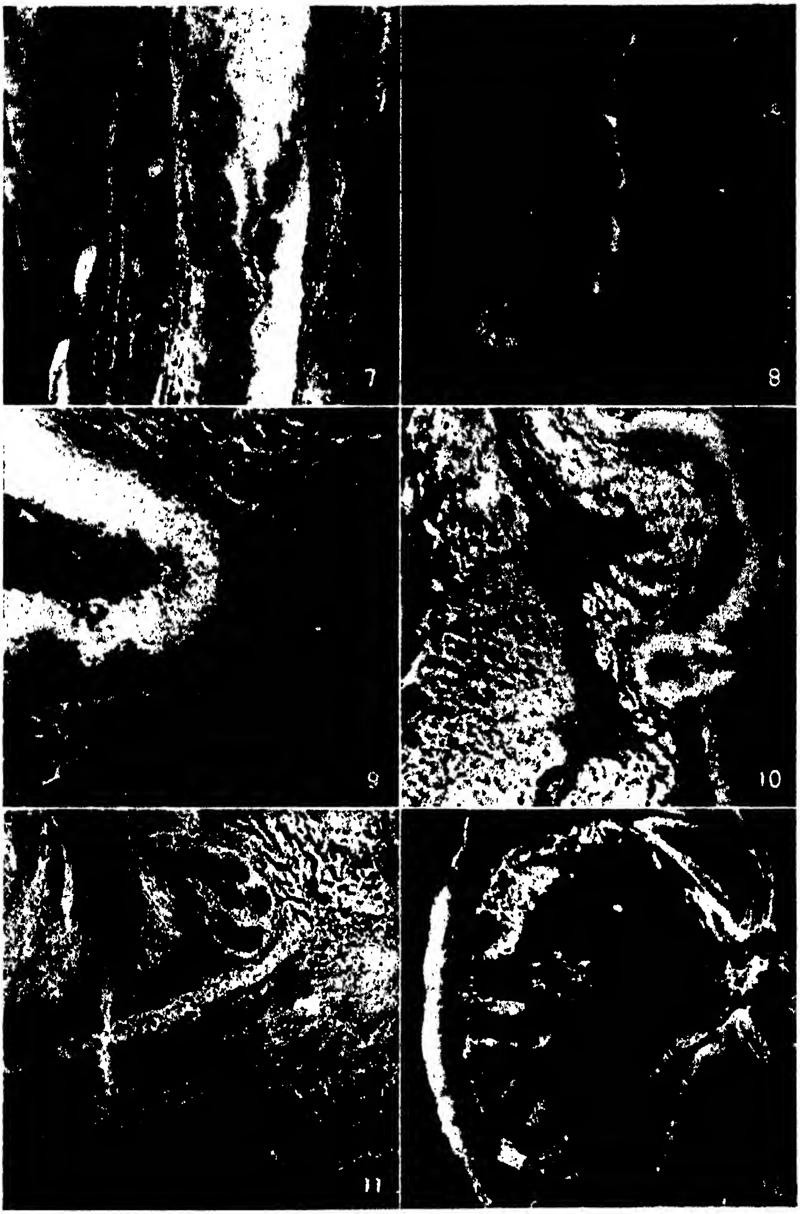


PLATE III

(Photomicrographs)

Showing comparative sizes during the crop's development. × .76.

Fig. 13. Eighth day.
Fig. 14. Tenth day.
Fig. 15. Fifteenth day.
Fig. 16. Twenty-first day.

PLATE III

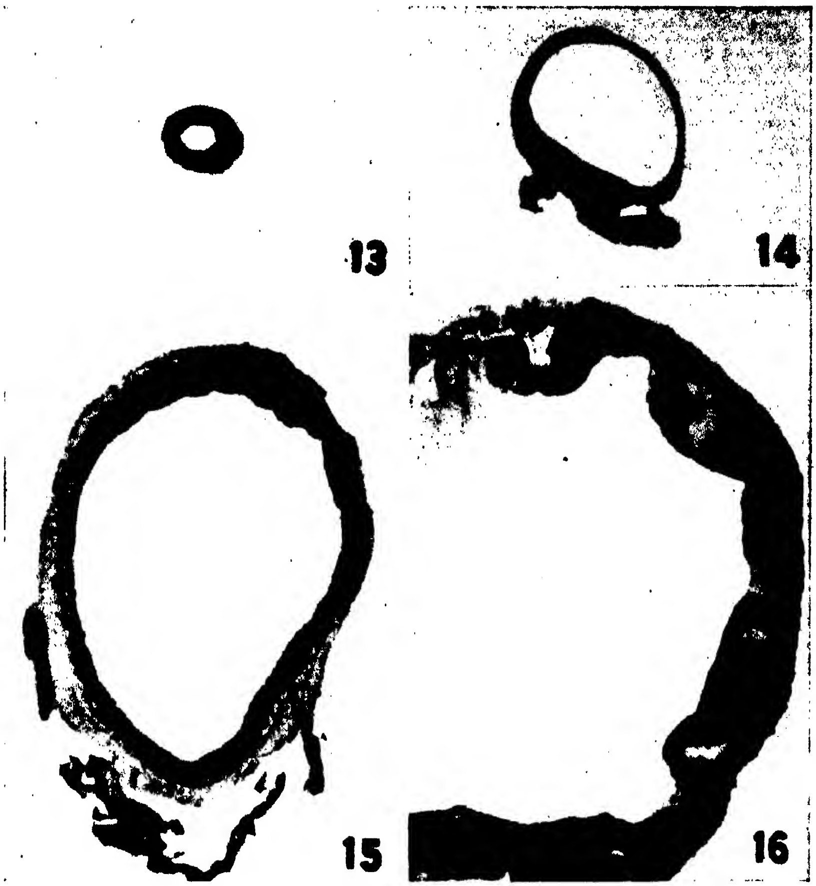


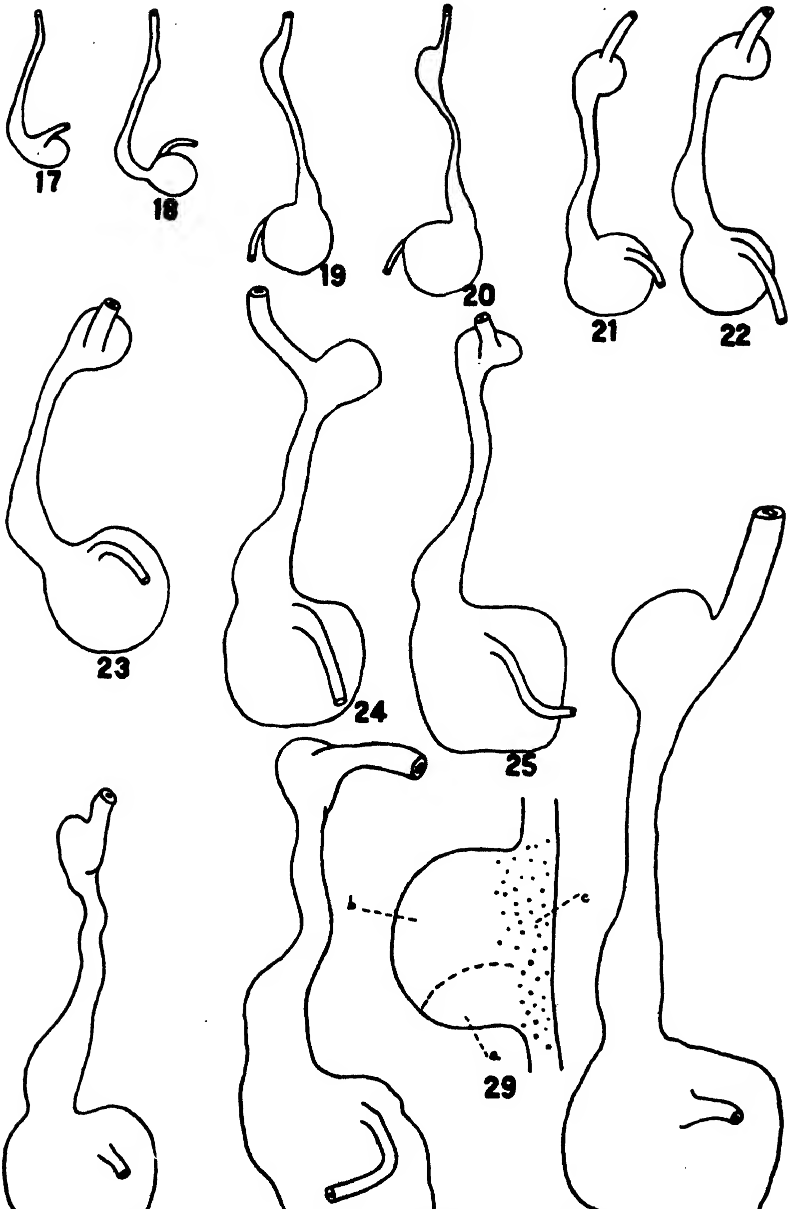
PLATE IV

Diagrammatic drawings showing the gross morphological developments of the chick's crop and gizzard during incubation. Figs. 17-28. $\times$ 2.

Fig. 17. Seventh day.
Fig. 18. Eighth day.
Fig. 19. Ninth day.
Fig. 20. Tenth day.
Fig. 21. Twelfth day.
Fig. 22. Thirteenth day.
Fig. 23. Fourteenth day.
Fig. 24. Fifteenth day.
Fig. 25. Sixteenth day.
Fig. 26. Seventeenth day.
Fig. 27. Nineteenth day.
Fig. 28. Twenty-first day.

Fig. 29. Adult crop: (*a*) Thick-walled area, (*b*) thinner-walled area, and (*c*) location of glands.

PLATE IV



Notes on the Behavior of a Small Amoeba of the Genus Naegleria

A. W. McCULLOUGH, University of Kansas, Lawrence, Kan.

The genus Naegleria occupies the lowest position in the Family Trimastigamoebidae, which in turn is the lowest family of the naked lobose rhizopods, according to Shaeffer.[1] The genus, as amended by Calkins,[2] comprises two species, *N. bistadialis* and *N. guberi*. The distinction is based upon the type of cyst formed.

It was the good fortune of the writer in the early months of 1934 to establish a rich culture of this genus in which *N. bistadialis* was dominant. The first of these organisms was isolated from a decomposing culture of larger amoebae secured from a biological supply house for class purposes. Local pools had supplied occasional forms, but previously it had proved impossible to culture them over any period of time due to the fact, as has been found since, that the cultures were not allowed to become sufficiently acid to further their best development.

Once established, the culture was readily continued by using large, flat dishes which were kept covered except for short periods each day while samples were being studied or while the cultures were being searched for the presence of rotifers. Occasional additions of *Naegleria* were made from local sources, care being exercised not to add rotifers, small crustacea or similar destructive forms. By early summer this culture had become so rich that two or three drops placed on a slide would usually show twenty to thirty organisms in a single low-powered microscope field. It was from this rich culture that the following studies and observations were made.

Naegleria is a small amoeba measuring roughly 20μ in length in its trophic form. It is readily recognized by its characteristic shape and movement. As will be seen, it forms short, blunt, and usually angular pseudopodia. It moves slowly, often not changing its general elongate shape except for the alternate formation and decline of pseudopodia on the anterior margin. Its ectoplasmic and endoplasmic regions are quite clearly defined, the former being very free of granulation and wide proportionally, especially in the anterior margin (a fact which suggests its near relationship to Valkampfia, the next higher genus of the family).

The endoplasm is quite granulated, often shows large, clear vacuoles, is invariably free from crystalline structures, and may contain numerous food vacuoles of which decomposing organic material and bacteria are the more common contents.

The nucleus is large in proportion to the animal and carries a large, centrally located karyosome. Otherwise the nucleoplasm is quite homogeneous, showing a fine granulation that appears clear in comparison to the surrounding endoplasm. There are statements in the literature which credit Naegleria with having a vacuolated nucleus, under certain conditions. This may be true, but it has not been noted in some 600 specimens studied in recent months.

1. Shaeffer, A. A.: Papers from Dept. of Marine Biology, Carnegie Inst. of Wash., D. C. vol. 24.

2. Calkins, G. N.: 1913, Genera and Species of Amoeba. Trans. 15th Internat. Cong. Hyg. and Demography.

This amoeba differs from all others of the order in assuming a biflagellate stage under certain culture conditions. Chief among these is that of the hydrogen ion concentration of the culture fluid. The optimum pH for free trophic movement and reproduction is slightly on the acid side of neutrality. Brom thymol blue was used for study of the optimum habitat pH, since its span of break includes neutrality and extends about equidistant on each side of it. When the acidity of the culture was increased by the addition of acetic acid to such point that a break was evident in brom cresol purple (roughly a pH of 6 to 6.5) and left for 30 minutes, a large part of the organisms assumed flagellate form and were found to be surprisingly motile and no longer confined to the substrate. If the acidity was carried further to the breaking point of methyl red (roughly pH 5) the organisms, regardless of whether flagellated or not, assumed a cystic condition and ceased all activity. A similar encystment could be produced by swinging an optimum culture toward the alkaline side of neutrality by the addition of lithium carbonate to the breaking point of phenol red (roughly pH 8). Thus it might be generalized that when the habitat becomes inclement the biflagellate form is assumed to facilitate motility. In the confines of the experimental set-up where escape is impossible further inclemency is met by the characteristic device of encystment.

The process by which the flagellated stage is attained is not entirely clear after repeated observations of the change. Certain attendant phenomena are readily noted, and it is possible to predict by the succession of these the approximate time at which the organism will become motile in its flagellated form. But the flagella themselves are usually first actually visible at the time they begin their lashing to propel the organism, at which time, of course, they are fully formed and functional. An amoeba about to undergo this change ceases all trophic activity, including protoplasmic streaming. It assumes elongate form, and any pseudopodia which happen to be present at the time of cessation of movement slowly loose their sharp angularity. The nucleus is seen to occupy a position in the anterior third of the endoplasm or very slowly, almost imperceptibly, move to such position. The line of demarkation between the endoplasm and ectoplasm becomes less distinct, especially anteriorly, and some time later the nucleus is seen to occupy about the region where such line of demarkation formerly existed. Movement may then occur at any moment. It takes place usually both in an anterior and upward direction. As movement begins, close observation reveals a fine, thin flagellum extending anteriorly, sometimes as long as the entire organism, but usually slightly shorter. A shorter flagellum, which seems to be less actively engaged in the process of locomotion, may be at once distinguished, may be observed only after some period of time (and in some cases may not be seen at all), which seems to arise from the same region of the margin as the larger. All observations of the writer suggest that the nucleus, in its anterior position, serves as a basal body for the flagella. In some instances an attaching structure has been seen extending from the nucleus to the point of marginal attachment of the flagella. Any parabasal or paranuclear body, such as is suggested in certain drawings by English observers of this organism, has not been observed in the living forms studied.

Deflagellation has been observed in a few instances in the natural cultures of these organisms. The flagellated form settles to the substrate and all vibra-

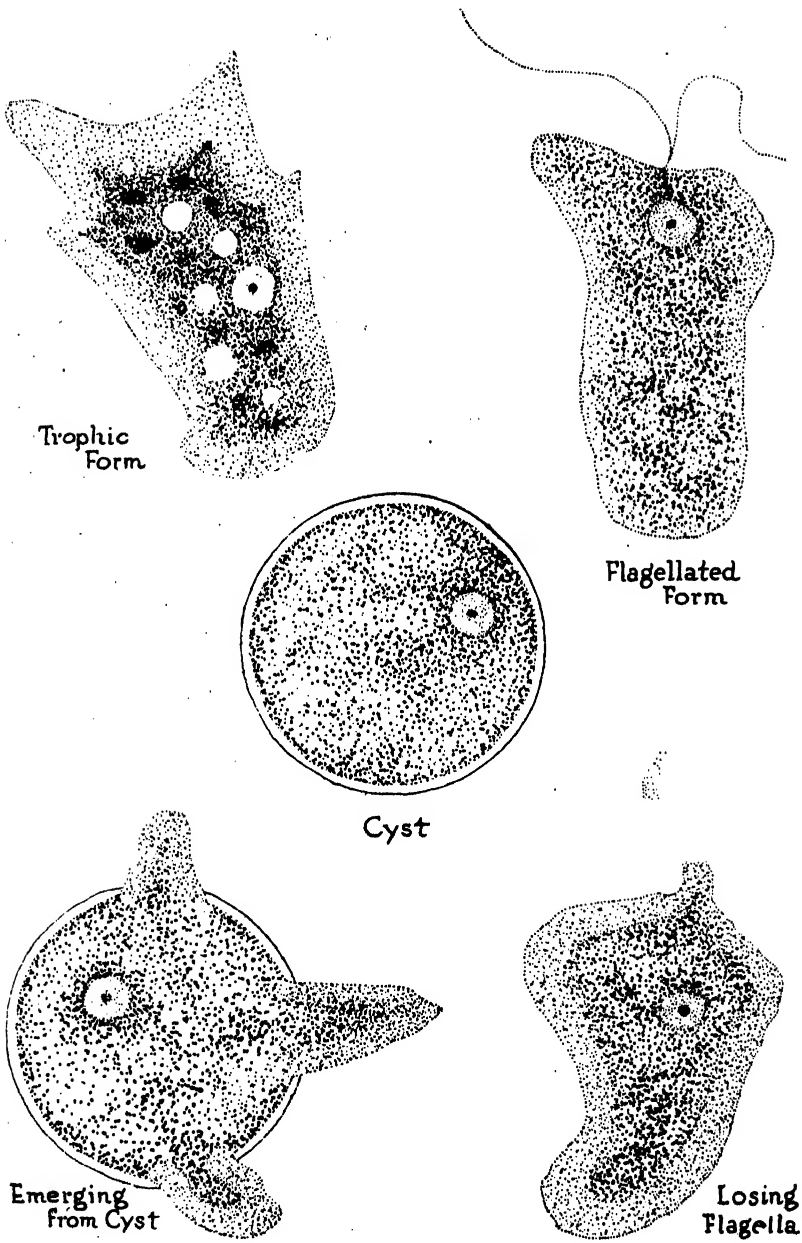
tion of the flagella ceases. The body form becomes slowly oval and may become almost circular in outline; the proximal ⅛ of the original and longer flagellum is seen to thicken to almost the proportions of a long, slender pseudopod. Whether this thickening is due to the resorption of the distal ⅞ of the structure and possibly, also, its associated shorter flagellum, cannot be said. It would seem probable this is the case. Slowly the thickened basal region is resorbed by the body cytoplasm, the endoplasm and ectoplasm again become distinguishable and shortly thereafter streaming and pseudopod formation is resumed.

Encystment in Naegleria seems to be a wholly protective function. Conditions under which it encysts have been mentioned above. An organism about to encyst ceases trophic movement, streaming ceases or becomes very slight, its general shape becomes oval or circular in outline and a surrounding wall slowly appears to encase the organism, in which the nucleus seems to undergo little or no change. The cyst wall seems to be secreted by the cytoplasm, but such secretion, if this is its origin, does not produce a decrease in the mass of the organism, so far as can be seen. In fact the contrary seems to be the case, for the mass of the contents of the cyst seems to be somewhat greater than that of the trophic organism. This may be due to the imbibition of water in anticipation of the desiccation that, in nature, is often the sequel to encystment.

Decystment is, in general, the reverse of the above process. The cyst wall is seen to dissolve in certain places, two or more often occurring simultaneously. From these the cytoplasm protrudes itself as pseudopodia, streaming in the endoplasm increases, and, as the organism moves off in trophic form, the remaining portions of the cyst wall slowly become indistinguishable. In one instance an organism moved but a short distance from its place of decystment before ceasing activity for a period of thirty minutes and then divided. This observation would seem to agree with the generally accepted view that multiplication in this form does not occur in the cystic stage.

The times required for the above changes may be of interest. Flagellation, in one instance, was observed to be completed in eighteen minutes. Usually the time required was from forty minutes to as long as one hour and forty-eight minutes. Deflagellation usually requires longer, the time being roughly from one to two hours. Encystment, in some cases, may progress quite rapidly, fifteen to twenty minutes permitting its completion in so far as one could observe. Decystment is less rapid, the time being usually roughly forty minutes to an hour, although it must be kept in mind that accurate timing of either of these processes is impossible because one is unable to say exactly at what instant encystment ceases or decystment begins.

The reactions of Naegleria with respect to light have been studied rather thoroughly. Time will not permit a detailed account of these reactions here nor of the experimental set-up by which they have been produced. In general it may be said that, in keeping with the behavior shown by larger and more highly evolved amoebae, Naegleria reacts to differentials of light intensity rather than to given intensity values. It shows a definite progressive adaptation to repetition of the same experimental situations which, I think, may be called learning without extending the meaning of the term. These reactions and their significance are the subject of papers now in the process of preparation.


Trophic Form
Flagellated Form
Cyst
Emerging From Cyst
Losing Flagella

Notes on a Small Herpetological Collection from Western Australia

EDWARD H. TAYLOR, University of Kansas, Lawrence, Kan.

The material on which the following notes are based was collected in Perth, Western Australia, by Prof. George Nichols. These were sent to me some time ago, and the data recorded. It seems wise that this data be made available to other workers.

Myobatrachus gouldii (Gray)

Breviceps gouldii Gray, J. Exp. Australia, vol. 2, p. 448, pl. 1, fig. 1.

The lot contains a single specimen (No. 2000)* of this strange termite-eating toad. It is presumably confined to Western Australia. The laterally expanded skin, which involves much of the limbs, erroneously suggests a glissant animal rather than a burrower.

The specimen is colored a very light, uniform tan. Length, snout to vent, 35 mm.

Pseudophryne mjöbergi Anderson

Pseudophryne mjöberti Anderson, Svenska Ak. Handl., vol. 52, No. 4, 1913, p. 19, pl. 1, figs. 5, 6.

A single specimen (No. 2001) of this diminutive toad is in the collection.

No vomerine teeth; a large subgular vocal sac, opening on either side of the tongue by large triangular openings; parotoid very indistinct or absent; interorbital distance equal to, or slightly greater than, the width of upper eyelid. Skin generally smooth, with two large smooth folds beginning about midway on the back and continuing to the groin; numerous wrinkled folds in anal region. Fingers and toes without webs. Two well-defined palmar tubercles and two large metatarsal tubercles, the inner elongate, longer than the first toe; the outer, arising a little farther posteriorly, is much shorter and rounded. Above brownish gray, sides with brownish spots. Below grayish yellow with scattered, distinct, brown spots.

This specimen differs from the typical in certain characters, especially in the strong marking of the ventral surface.

Hyla aurea Lesson

Hyla aurea Lesson, Voy. Coquille, vol. 2, p. 60; Rept., pl. 7, fig. 2.

One medium-sized specimen of this brightly colored tree frog is in the collection (No. 2003), together with a young, recently transformed specimen (No. 2004), which lacks the typical coloration.

Vomerine teeth in two somewhat oval series, lying directly between the choanae, and occupying nearly two thirds of the distance between them; the teeth are elongate and strongly curved. Tongue oval, with a well-defined central depression; tympanum very distinct, about two thirds the diameter of the eye; nostril slightly closer to the tip of the snout than to the eye; interorbital width much greater than width of eyelid. The fingers with the

* Numbers refer to the E. H. Taylor collection on deposit at the University of Kansas.

terminal pads slightly wider than fingers with narrow dermal fringes; a slight web is evident between the inner fingers; first finger shorter than the second; a strongly defined longitudinal pad on the proximal part of the first finger, and a large, partially divided palmar pad; tibiotarsal articulation reaches the eye; terminal discs on toes relatively narrow, scarcely as wide as the toe; toes about three fourths webbed; a small outer metatarsal tubercle at base of fourth metatarsal, and a sharply defined inner tubercle; a well-defined, narrow skinfold follows the inner edge of the foot behind the tubercle. Skin nearly smooth above, heavily granular on belly and femur; chin and breast indistinctly granular. Ground color above, brown; a median golden line terminating anteriorly between the eyes; two short golden lines on each side of the back; a line follows the rounded canthal line of the snout across the eyelid, and back to the groin; below immaculate cream.

The specimen differs from typical descriptions in the more forward position of the vomerine teeth; the very much larger choanae; the slight digital web on the hand and a small outer metatarsal tubercle. It may be that a large series will show that there is variation in these characters. Were these differences constant it seems likely that the form should be recognized subspecifically.

Hyla adelaidensis Gray

Hyla adelaidensis Gray, J. Exp. Australia, vol. 2, p. 447, pl. 8, figs. 1, 2.

Four specimens, Nos. 2005, 2006, 2008 and 2009, all immature, from Perth, Australia.

These show the very characteristic color and markings. The lateral golden yellow stripe begins behind the eye and runs along the side of the abdomen, where it stops. The groin has numerous small, yellow spots. The back and upper surface of the limbs are purplish. The posterior side of the thigh is blackish purple, with strongly defined, large cream spots.

A strongly defined fold is present across the breast, connecting the arms.

Number 2005 differs from the other two in having a narrow, brownish longitudinal line in the middle of the back, and two rather dull purplish dorsolateral lines bordered by a few brownish dots above.

Helioporus albo-punctatus Gray

Helioporus albo-punctatus Gray, J. Exp. Australia, vol. 2, 1841, p. 447, pl. 2, fig. 1.

Three specimens, Nos. 2010, 2011 and 2012, from Perth, western Australia. In these specimens the tympanum, while covered with skin, shows its outline rather clearly. The vomerine teeth are on two strongly raised prominences directly between the choanae, the teeth in a single row, the two series meeting medially in the depression between the prominences; choanae large, circular; no canthus rostralis. In profile the snout is strongly angled, the nostrils a little nearer the eye than the tip of snout; anterior outline of the head nearly circular; the interorbital width less than an upper eyelid; the tibiotarsal articulation reaches the edge of the tympanum.

First finger longer than second, which in turn is longer than the fourth; a strongly enlarged, elongate palmar tubercle on the base of the first toe, and two small ones on the posterior part of the palm; well-defined subarticular tubercles at the base of the digits, the third finger with another one at the first

joint; palm covered with large rounded granules; web between the toes short, thickened on its edge; toes slightly flattened, the short inner toe nearly as wide as long; second toe rather flattened, more or less rounded at the tip. Other toes with more or less bluntly pointed tips. The inner metatarsal tubercle large, shovel-like; a slight fold follows it behind and a second rather indistinct fold is present near the outer side of the foot; the subarticular tubercles much smaller than those on fingers.

Light brown above, with lighter, rounded, wavy marks; on each specimen is a broad, brown band extending nearly half the length of the body; head with very indistinct markings.

The specimens are males, but lack nuptial asperities. Snout to vent, 55 mm., 49 mm., and 50 mm., respectively.

Limnodynastes dorsalis dorsalis (Gray)

Cystignathus dorsalis Gray, J. Exp. Australia, vol. 2, 1845, p. 446.

Three specimens of this well-known form (Nos. 2013, 2014 and 2015) are in the collection, from Perth, Western Australia.

The two former specimens are similarly marked; a median yellowish line runs from the tip of the snout to the anus (the ground color is yellowish-olive or tan in the younger of the two). The lip has a dark-brown spot below the eye; a broad line begins near the tip of the snout, runs back over the side of the head, and terminates above the front leg; it is interrupted by the eye and involves the whole of the tympanum. A pair of large, dark-brown spots are on the head, each sending a broad arm across the upper eyelid; these are followed by two elongate spots, a third the length of the body, bordering the median line. Sides and posterior parts of body with rounded or elongate spots; a few irregular orange spots in the groin; femur reticulated with olive and brown. The large glandular area on the tibia is strongly barred with black-brown and cream above; a large light spot on under side of tibia.

In No. 2015 the dorsal and lateral markings are very indistinct.

Crinia georgiana georgiana Tschudi

Crinia georgiana Tschudi, Classif. Batr., 1838, p. 78.

Two specimens of the typical form are in the collection (Nos. 2016, 2017).

Crinia signifera (Girard)

Ranidella signifera Girard, Proc. Acad. Nat. Sci., Phila., vol. 6, 1853, pp. 421-422.

Two specimens of this extremely variable form are in the collection (Nos. 2018, 2019).

Number 2019 has the belly covered with broad, flat granules; distinct dorsolateral folds present, with numerous smaller warts or tubercles between them. A pair of brown stripes are present in the dorsolateral region. Belly white, with a few elongate, deep brown markings.

Number 2018 has the dorsolateral folds obsolete, the dorsal markings indefinite. The belly is brownish white, with numerous brown markings.

An examination of a large series of this species from Australia will doubtless cause the recognition of certain of the numerous described forms now placed in synonymy.

Typhlops bituberculatus Peters

Typhlops bituberculatus Peters, Monats. Akad. Berlin, 1868, p. 288.

One specimen, from Perth, Australia (No. 2003).

There are twenty scale rows around the body; 580 scales in a row from snout to vent; 27 under the tail. The tip of the snout is flattened, with a sharp transverse edge, deflected downward at the tip. The small tubercular prominences about the nasals are quite distinct, giving the anterior head outline a trilobed appearance. The tail is somewhat flattened below. Total length, 438 mm.; tail length, 14 mm.; tail width, 6 mm.; vertebra along middle of body, 1.5 mm. long.

Proposed Changes in the Nomenclature of the Scincoid Lizard Genus Eumeces

EDWARD H. TAYLOR, University of Kansas, Lawrence, Kan.

Having completed a study of the various species of the genus Eumeces, I have found it necessary to describe certain new forms, place certain forms in synonymy, and resurrect others from synonymy. I present this list of proposed changes preliminary to the publication of my monograph on the genus. Certain of these changes have been suggested in my previous publications. As a bibliography is given in the complete work, none is appended here.

Eumeces egregius egregius (Baird). The typical form is insular, probably extending along the east coast of Florida.

Eumeces egregius onocrepis (Cope). This form, long placed in the synonymy of *egregius*, is recognized. Errors in the original description and the condition of the types may have caused Cope to place the form in synonymy.

Eumeces fasciatus (Linnaeus). This name is restricted to the small, five-lined lizard which occurs from the central part of the United States to the Atlantic (part of peninsular Florida excepted).

Eumeces laticeps (Schneider).[1] This name is used for the large seven- and five-lined forms of the southern United States.

Eumeces inexpectatus Taylor. This name is used for the third southern species long confused under the name *fasciatus*. If the types of Cope's *polygrammus* (1900) can be found, and it proves to be of this form, his name will have precedence.

Eumeces multivirgatus obtusirostris (Bocourt). The name *obtusirostris* was "published" with a series of key characters and plates in 1879; the complete description appeared later in 1881. Cope's name *pachyurus* (1880) is thus antedated. *Obtusirostris* is not a synonym of *tetragrammus* as believed by Boulenger and Cope.

Eumeces pluvialis Cope. The characters on which Cope based this species are characters present in the young of *anthracinus* (Baird). Unless a much greater amount of material is made available and new characters are discerned on which a separation can be based, I believe this form should remain a synonym of *anthracinus* (Baird).

Eumeces skiltonianus (Baird and Girard). This name is restricted to include only the small western species which retains its lines throughout life.

Eumeces gilberti gilberti Van Denburgh. The northern blue-tailed mountain skink is recognized as a well-defined subspecies.

Eumeces gilberti rubricaudus is a red-tailed form extending in the valley region of the San Joaquin river south into Baja California. (Description in press.)

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1. The 1938 edition of the Stejneger and Barbour checklist does not recognize this and the following form.

Eumeces lagunensis Van Denburgh. This species occurs in the lower half of the peninsula of Baja California. It is differentiated on the characteristics of the temporals.

Eumeces rovirosae Dugès. This nominal species is apparently the young of *Eumeces sumichrasti* (Cope), and is placed in the synonymy of the latter species.

Eumeces schmidti Dunn. This nominal species appears to be a middle-aged specimen of *Eumeces sumichrasti* (Cope) still showing the characteristic markings of the young. It is not surprising that this and the above form were regarded as distinct, since the type, which is a large male, is uniformly colored, lacking all markings. Larger series of specimens of both the above species may show characters not now in evidence that might warrant the retention of one or both names as subspecies.

Eumeces taeniolatus (Blyth) (non *taeniolatus* Boulenger, 1887) is the name for the Indian species which Boulenger and other authors refer to *E. scutatus* Theobald. The latter name was founded on the same types as *Eurylepis taeniolatus* Blyth, but ten years later, and hence has no place save in synonymy. The *Eumeces taeniolatus* described in Boulenger's Catalog (Vol. III, p. 383) appears to be a species (*Eumeces managuae*) recently described from Central America by Dunn. I have examined the specimen and the differences are not greater than might be normally expected in a species. I think it highly probable that the specimen originated in Central America, rather than in India. Boulenger gives no locality data with the specimen.

Eumeces lynxe furcirostris (Cope). This species of Cope's is recognized as a subspecies of *Eumeces lynxe* (Wiegmann), characterized by three instead of four supraoculars.

Eumeces bellii (Gray). On the basis of photographs of the type of this species, it has been possible to refer this form to the synonymy of *Eumeces lynxe lynxe* (Wiegmann).

Eumeces chinensis pulcher (Duméril and Bibron). This form is considered as worthy of only subspecific rank.

Eumeces chinensis formosensis Van Denburgh. This form is placed in the synonymy of *Eumeces chinensis chinensis* (Gray).

Eumeces latiscutatus okadae (Stejneger) is recognized as a distinct species.

Eumeces marginatus amamiensis Van Denburgh is placed in the synonymy of *Eumeces oshimensis* Thompson on the basis of priority. Thompson's description bears the date June 28, 1912; Van Denburgh's paper is dated July 29, 1912.

Eumeces marginatus kikaigensis Van Denburgh is placed in the synonymy of *Eumeces oshimensis* Thompson. Van Denburgh's statement that this form has three pairs of nuchals is due to error. It has the same number as the preceding form.

Eumeces ishigakiensis Van Denburgh is placed in the synonymy of *Eumeces stimsonii* Thompson on the basis of priority (see above dates of publication).

Eumeces pekinensis Stejneger. On the basis of photographs of the types, and later an examination of one of them, this species is placed in the synonymy of *Eumeces xanthi* Günther. Günther's description is so brief, omitting as it does some of the most pertinent characters, that it is small wonder that in the absence of the types *pekinensis* was described as new.

Eumeces zaroudnyi Nikolski. This form is tentatively recognized as a distinct species.

Eumeces algeriensis meridionalis Domergue is recognized as a subspecies.

The following species whose descriptions are now in press are added to the list of species: *Eumeces colimensis* (Colima, Mexico) and *Eumeces gaigei* (Taos, New Mexico).

Description of Amphibian Tracks Found at Osage, Kansas

LYMAN C. WOOSTER, Kansas State Teachers College, Emporia, Kan.

For nearly thirty years there has been standing in the museum of the Kansas State Teachers College of Emporia a slab of calcareous shale pitted with the foot tracks of an amphibian. The slab dates from the middle Pennsylvanian, making the tracks 15 million years old (or about 150 million years old according to the Osborne chronology). These are tracks of the first land animals.

Forty years ago Professor Marsh of Yale described five sets of tracks on a slab twelve feet square from Osage, Kansas. These are pictured in Dana's Manual of Geology, page 684, 4th edition. Those in figure 1116 are much like those on the slab at Emporia, especially the smaller tracks on the Emporia slab.

As shown in the photograph accompanying this paper the large tracks are closely followed by the small tracks on the left side, but no small tracks are shown on the right side. The stride of the animal was 9 inches and its width, as shown by the tracks, was 7.5 inches. If all the tracks were made by one animal, the large ones were made by the hind feet and the small ones by the front feet. All the tracks show four toes, but one on the left, the middle one, shows a fifth toe.

Notes on the Effects of Drought on Animal Population in Western Kansas

L. D. WOOSTER, Fort Hays Kansas State College

The drought of the past two summers has had varying effects on animal life—effects not always foreseen. It is the purpose of this report to record effects on vertebrate animals as observed in the western half of Kansas during the summers of 1933 and 1934. Two species on which the effects have been opposite are discussed particularly.

First of all, the drought has had the rather surprising effect of increasing the number of black-tailed jackrabbits, *Lepus californicus melanotis* (Mearns), in this territory. So numerous have these rabbits become that scores of rabbit drives have been held throughout the western third of the state through the winter and spring of 1934-'35, in an attempt to reduce their numbers. From a few hundred to thousands of these animals have been killed in the various drives.

To anyone who has lived in Western Kansas for many years it has been quite apparent that the jackrabbits were decidedly more numerous than usual. But in order to obtain more definite figures as to the increase, counts were recently made on a prairie area in Ellis county where similar counts had been made in previous years. The counts were made by the transect-survey method.

In this method a group of people marched in line, ten feet apart, for one mile and counted all jackrabbits scared up within the path of march. From the number of rabbits counted on this fraction of a square mile, was estimated the number for a common unit-area, in this case one square mile.

By this method, in November, 1933, 175 rabbits were estimated per square mile on a prairie area in Ellis county; in November, 1934, a year later, 406 were estimated on the same area. In March, 1933, 158, and in March, 1935, two years later, 484 were estimated on the same area. In March, 1935, the number was therefore over three times as many as at the same time in 1933.

It is quite evident, both from general observation and from actual count, that the black-tailed jackrabbits have become more numerous than usual after two summers of drought.

Why have they become more numerous? So far no positive proof is available on this point. Three possible explanations have been suggested:

(1) Actual increase in number of young produced.

(2) Lower than usual mortality rate, especially of young.

(3) Immigration of rabbits from other regions.

The first suggestion seems the least plausible of the three. Increased production of numbers of young is commonly considered to be an accompaniment of plentiful food supply. The last two summers have provided scanty food and water supply. Hence one would expect the rabbits to be less prolific rather than more so.

The second suggestion, low mortality rate, especially among the young, is commonly mentioned as a cause of unusual numbers by those who live on farms where they have opportunity to observe and gain impressions of natural

processes. Their claim is that the chilling rains and wet soil of spring and early summer kill large numbers of young; the last two seasons have been dry and warm; therefore more of the young produced have grown to maturity. The theory seems reasonable.

For the third suggestion, namely that the rabbits migrate in from other regions, there is no authentic evidence. Rabbits undoubtedly shift gradually from area to area within limits, but there is no evidence that the black-tail makes wholesale, long-distance migrations. If it did, why should it select for its destination the driest, most barren parts of Kansas this year? The food supply would have been much better in other places.

So of the three suggested causes of jackrabbit increase, the second one mentioned, namely, low mortality of young due to favorable developing seasons, seems the most plausible.

At any rate the black-tailed jackrabbit has shown marked increase in the winter of the second of two dry years and following two dry, hot summers.

The most marked decrease in numbers observed in any mammal has been that of the meadow mouse, *Microtus haydeni* (Baird). Two years ago the runways of this species could be found almost anywhere on the prairie or in weedy places where grass or weeds furnished sufficient cover; and the animals could be caught in traps at any time. In the past two growing seasons, little bluestem (*Andropogon scoparius*), other grasses and weeds have scarcely grown at all, certainly not enough to produce cover for the runways of *Microtus*. Without runways these mice are easy prey for hawks, owls, coyotes, etc. During the past winter search has been made for runways, and traps have been set in likely places, yet not a runway has been found nor a single meadow mouse caught. On the other hand, deer mice (Peromyscus) have been caught as commonly as ever.

Large hawks have been more numerous over the rabbit areas. This, however, has probably been due to a localizing or concentrating of numbers rather than to actual increase.

Dickcissels, *Spiza americana* (Gmel.), commonly abundant on the prairies of western Kansas in the summer, were surprisingly scarce during the summers of 1933 and 1934. After the migrating season was over in 1933 no dickcissels were seen through the summer. During the summer of 1934 one pair only was seen by the writer in the area about Hays.

Ponds that are usually considered "permanent" have dried up, and with them the fishes. Necessarily amphibia have disappeared and, of course, have not produced their usual quota of young.

What the effect of drought has been on carnivora, such as the coyote, badger, and skunk, it is thus far impossible to say. One would expect that an increase in jackrabbits as a food supply would increase the coyote population. However, such increase would presumably trail by a year the increase in rabbit population. It will be of interest to watch for evidence of changes, if any, in the coyote population in the coming year.

It is too early to determine the full effects of drought on vertebrate animal life in western Kansas, but those here reported are the more conspicuous instances observed thus far.

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